भारतीय मानक
Indian Standard

IS 17773 : 2022

संवृत-परिपथ अमोनिया प्रशीतन प्रणाली — डिजाइन और संस्थापन की रीति संहिता (एएनएसआई/आईआईएआर 2 : 2014, एनईक्यू)

Closed-Circuit Ammonia Refrigeration System — Code of Practice for Design and Installation (ANSI/IIAR 2 : 2014, NEQ)

ICS 71.060; 13.300; 27.200

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September 2022 **Price Group 16**

Refrigeration and Air Conditioning Sectional Committee, MED 03

FOREWORD

This Indian Standard was adopted by the Bureau of Indian Standards, after the draft finalized by the Refrigeration and Air Conditioning Sectional Committee had been approved by the Mechanical Engineering Division Council.

This standard provides the recommended practice for safe design, and installation of closed-circuit ammonia mechanical refrigerating systems. It lays down the requirements for safety of persons and property on or near the premises where the refrigerating systems are located. Additional requirements may be necessary because of particular circumstances, project specifications or other jurisdictional considerations. This standard is not intended to serve as a comprehensive technical design manual and shall not be used as such.

Experience shows that ammonia is difficult to ignite above 650°C and is very stable under normal conditions. The ignition point of ammonia is limited to a range of 160 000 ppm to 250 000 ppm. This concentration far exceeds the 50 ppm Permissible Exposure Level (PEL) published by National Institute for Occupational Safety and Health (NIOSH), United State of America. For any deviation between the waste constituents with concentration limits specified in this standard and the limits specified in the *Hazardous and Other Waste (Management and Transboundary Movement) Rules*, 2016 issued by Ministry of Environment, Forest and Climate Change, the limits specified in rules shall prevail.

Ammonia’s strong odour alerts those nearby to its presence at levels well below those that present a hazard. This “self-alarming” odour is so strong that a person is unlikely to voluntarily remain in an area where ammonia concentrations are hazardous.

The principal hazard to persons is ammonia vapour, since exposure occurs more readily by inhalation than by other routes. As with any hazardous vapour, adequate ventilation is the key to effective control.

Ammonia in vapour form is lighter than air. Ammonia vapour rises and diffuses simultaneously when released into the atmosphere. It is biodegradable, and when released, it combines readily with water and/or carbon dioxide to form relatively harmless compounds. Ammonia may also neutralize acidic pollutants in the atmosphere.

Assistance has been drawn from the following publications in formulation of this standard:

ANSI/IIAR 2 : 2014	Safe design of closed-circuit ammonia refrigeration systems
AAR-1 : 2016	Safe design of closed-circuit ammonia refrigeration systems (For Indian conditions)

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The composition of the Committee responsible for the formulation of this standard is given in Annex L.

For the purpose of deciding whether a particular requirement of this standard is complied with the final value, observed or calculated, expressing the rules of the test or analysis shall be rounded off in accordance with IS 2 : 2022 ‘Rules for rounding off numerical values (*second revision*)’. The number of significant places retained in the rounded off value should be the same as that of the specified value in this standard.

CONTENTS

Page No.

SECTION 1 GENERAL

1 SCOPE ... 1
2 REFERENCES ... 1
3 TERMINOLOGY ... 2

SECTION 2: DESIGN AND INSTALLATION CONSIDERATIONS AFFECTING CONSTRUCTION

4 LOCATION OF AMMONIA REFRIGERATION MACHINERY ... 9
5 GENERAL SYSTEM DESIGN REQUIREMENTS ... 10
6 MACHINE ROOMS ... 19
7 AREAS OTHER THAN MACHINE ROOMS ... 24

SECTION 3 : EQUIPMENT AND COMPONENTS

8 COMPRESSORS ... 27
9 REFRIGERANT PUMPS ... 29
10 CONDENSERS ... 30
11 EVAPORATORS ... 33
12 PRESSURE VESSELS ... 36
13 PIPING ... 38
14 PACKAGED SYSTEMS AND COMPONENTS ... 40
15 OVER PRESSURE PROTECTION DEVICES ... 41
16 INSTRUMENTATION AND CONTROLS ... 46
17 AMMONIA DETECTION AND ALARMS ... 47

SECTION 4

ANNEX A ALLOWABLE EQUIVALENT LENGTH OF DISCHARGE PIPING ... 49

ANNEX B METHODS FOR CALCULATING RELIEF VALVE CAPACITY FOR HEAT EXCHANGER INTERNAL LOADS ... 51

ANNEX C DUPLICATE NAMEPLATES ON PRESSURE VESSELS ... 57

ANNEX D STRESS CORROSION CRACKING ... 57

ANNEX E EMERGENCY PRESSURE CONTROL SYSTEMS EMERGENCY PRESSURE CONTROL SYSTEM DESIGN AND INSTALLATION GUIDELINES ... 58

ANNEX F MACHINE ROOM SIGNS ... 61

ANNEX G ALTERNATIVE VENTILATION CALCULATION METHODS ... 64

ANNEX H PIPE FITTINGS, FLANGES AND BOLTING ... 66

ANNEX J SAFE PRACTICE IN CASE OF LEAK AFFECTING OCCUPANTS ... 71

ANNEX K PHYSICAL PROPERTIES OF AMMONIA ... 72

ANNEX L COMMITTEE COMPOSITION ... 74

LIST OF TABLES

Table 1 Purity Requirements ... 10
Table 2 Minimum Design Pressure ... 12
Table 3 Seamless Carbon Steel Pipe Data for Weld Joints ... 15
Table 4 Seamless Carbon Steel Pipe Data for Threaded Joints ... 15
Table 5 Seamless Stainless Steel Pipe Data for Weld Joints ... 16
Table 6 Seamless Stainless Steel Pipe Data for Threaded Joints ... 16
Table 7 Maximum Allowable Hanger Rod Spacing ... 16
Table 8 Recommended Minimum Thickness for Various Pressure Vessel Sizes (Ready Reckoner) ... 37
Table 9 Velocity Requirement for Line Sizing ... 38
Table 10 Safety Valve Capacity (Air) in kg/h for High Pressure Receivers ... 43
Table 11 Safety Valve Capacity (Air) in kg/h for Low Pressure Receivers ... 43
Table 12 Typical Moody Friction Factors, Steel Tubing Piping (NPS) ... 49
Table 13 Typical Moody Friction Factors, Steel Piping ... 50

LIST OF FIGURES

Fig. 1 Principal Machinery Room Door ... 62
Fig. 2 Auxiliary Machinery Room Door ... 63
Fig. 3 Elbow Drawing ... 66
Fig. 4 H3 Flange Drawing ... 70

Indian Standard

CLOSED-CIRCUIT AMMONIA REFRIGERATION SYSTEM — CODE OF PRACTICE FOR DESIGN AND INSTALLATION

SECTION 1 GENERAL

1 SCOPE

1.1 This standard covers the code of recommended practice for the safe design and installation of closed-circuit vapour compression ammonia refrigeration systems.

1.2 The requirements outlined in this standard apply to stationary closed-circuit mechanical refrigerating systems utilizing ammonia as the primary refrigerant.

1.3 This standard provides normative requirements relating to the equipment, design, safety, and installation of the following:

a) Stationary closed-circuit ammonia refrigerating systems and their components in industrial occupancies and limited charge self-contained systems for commercial occupancies; and

b) Indirect closed-circuit ammonia refrigerating systems for industrial, commercial, public assembly and large mercantile occupancies.

1.4 This standard does not apply to:

a) Ammonia absorption and adsorption refrigerating systems; and

b) Replacements of machinery, equipment or piping, meeting the functional equivalents.

1.5 Applicability

1.5.1 *Conflicts* — Where there is a conflict between this standard and the National Building Code of India or the National Electrical Code, the requirements of the code shall take precedence unless otherwise stated in such code.

2 REFERENCES

The standards listed below contain provisions which, through reference in this text, constitute provisions of this standard. At the time of publication, the editions indicated were valid. All standards are subject to revision and parties to agreements based on this standard are encouraged to investigate the possibility of applying the most recent editions of the standards listed below:

IS No.	*Title*
SP 7 : 2016	National building code of India (*third revision*)
SP 30 : 2011	National electrical code 2011 (*first revision*)
662 : 2020	Anhydrous ammonia — Specification (*second revision*)
778 : 1984	Specification for copper alloy gate, globe and check valves for water works purposes (*fourth revision*)
1239 (Part 1) : 2004	Steel tubes, tubulars and other wrought steel fittings: Part 1 Steel tubes (*sixth revision*)
1239 (Part 2) : 2011	Steel tubes, tubulars and other steel fittings: Part 2 Steel pipe fittings (*fifth revision*)
1703 : 2000	Water fittings — Copper alloy float valves (Horizontal plunger type) — Specification (*fourth revision*)
2002 : 2009	Steel plates for pressure vessels for intermediate and high temperature service including boilers (*third revision*)
2041 : 2009	Steel plates for pressure vessels used at moderate and low temperature (*third revision*)

IS No.	*Title*
3594 : 1991	Code of practice for fire safety of industrial buildings: General storage and warehousing including cold storage
3615 : 2020	Glossary of terms used in refrigeration and air conditioning (*second revision*)
3589 : 2001	Steel pipes for water and sewage (168.3 to 2 540 mm outside diameter) — Specification (*third revision*)
ISO 4126-1 : 2013	Safety devices for protection against excessive pressure: Part 1 Safety valves
4544 : 2000	Ammonia — Code of safety (*first revision*)
4503 : 1967	Shell and tube type heat exchangers
4671 : 2018	Expanded polystyrene for thermal insulation purposes — Specification (*first revision*)
ISO 5922 : 2005	Malleable cast iron
IS 8910 : 2010/ ISO 404 : 1992	General technical delivery requirements for steel and steel products (*first revision*)
ISO 21922 : 2021	Refrigerating systems and heat pumps — Valves — Requirements, testing and marking
11714 (Part 1 to 5) : 1986	Specification for steel tubes for heat exchangers
ISO 13971 : 2012	Refrigeration systems and heat pumps — Flexible pipe elements, vibration isolators, expansion joints and non-metallic tubes — Requirements and classification
ISO 14737 : 2021	Carbon and low alloy cast steels for general applications
16656 : 2017/ ISO 817 : 2014	Refrigerants — Designation and safety classification
16678 (Part 2) : 2018/ISO 5149 Part 2 : 2014	Refrigerating systems and heat pumps — Safety and environmental requirements: Part 2 Design, construction, testing, marking and documentation
16678 (Part 3) : 2018/ISO 5149-3: 2014	Refrigerating systems and heat pumps — Safety and environmental requirements: Part 3 Installation site

3 TERMINOLOGY

For the purpose of this standard, the definitions given in IS 3315 and the following shall apply.

3.1 Actuator — Mechanism for transmission of movement or force.

3.2 Acute-Toxicity Exposure Limit (ATEL) — The maximum recommended refrigerant concentration determined in accordance with the established systems and intended to reduce the risks of acute toxicity hazards to human in the event of a refrigerant release.

3.3 Accumulator — A low pressure vessel, separating refrigerant liquid and gas installed after the expansion device but before the liquid enters the evaporator in gravity flooded systems.

3.4 Air-Cooled Condenser — A refrigerant condenser in which heat removal is accomplished entirely by heat absorption by the air flowing over condensing surfaces.

3.5 Air-Cooled De-super-heater — A part of the system/equipment designed to cool the ammonia refrigerant vapour after it is discharged from the compressor and before it enters the condenser.

3.6 Air Cooler, Dry — It is a forced circulation air cooler wherein heat transfer is a combination consisting of air circulation and refrigerant cooling.

3.7 Air Cooler Spray Type — It is a forced circulation air cooler wherein the coil surface capacity is augmented by a liquid spray during the period of operation.

3.8 Air Duct — A tube or conduit for conveying air.

3.9 Ammonia — Refrigerant-grade anhydrous ammonia.

3.10 Approved — Acceptable to the jurisdictional authorities.

3.11 Approximate Lethal Concentration (ALC) — The concentration of a substance, or refrigerant in this standard, that was lethal to even a single test animal but no less than 50 percent of the animals in that group when tested by the same conditions as for an LC50 test.

3.12 Authorized Personnel — Persons who, have been specifically granted permission to enter a restricted area.

3.13 Automatic Expansion Valve — A controlling device that regulates the flow of the volatile mixture of refrigerant into an evaporator of a closed-circuit ammonia refrigerating system and which is actuated by evaporator pressure or temperature or liquid level.

3.14 Automatic Liquid Refrigerant Drain Valve — Valves provided for liquid ammonia condensate draining from hot gas defrost lines or other ammonia lines where liquid ammonia is likely to condense and accumulate.

3.15 Auxiliary Door — Any non-principal door communicating with a machinery room.

3.16 Booster Compressor — A compressor for discharging gas to the suction of a higher-stage compressor either directly or through an intermediate pressure vessel or heat exchanger.

3.17 Boiling Point — It is the temperature at which liquid changes its phase to vapour at atmospheric pressure at sea level.

3.18 Burning Velocity (S_u) — Velocity in cm/s, relative to the unburnt gas, at which a laminar flame propagates in the direction normal to the flame front, at the concentration of refrigerant with air giving the maximum velocity.

3.19 Building Code — The National Building Code of India.

3.20 Building Opening — A permanent or operable area that allows outdoor air in to the building envelope including operable doors (for example, swinging doors, slide doors, roll- up doors, fire doors, access hatches), operable make- up air intakes (where the intakes are not equipped with the ability to close automatically when ammonia is present), and other vents with permanent openings.

3.21 Cascade Refrigeration Systems — Two or more independent refrigerant circuits where the condenser of one system rejects heat in the evaporator of another system.

3.22 Closed-Circuit Ammonia Refrigerating System — A refrigerating system using mechanical compression to transfer the refrigerant from the low pressure side and to deliver it to the high pressure side of the system.

3.23 Compressor — A specific machine with or without accessories, for compressing ammonia refrigerant vapour. *See* also booster compressor, positive displacement compressor.

3.24 Compressor Positive Displacement — It is a refrigerant compressor in which increase of refrigerant gas/vapour pressure is attained by decreasing the internal volume of the compressor chamber.

3.25 Compressor Open — Compressor having a drive shaft penetrating the refrigerating tight housing.

3.26 Coefficient of Performance (Refrigerating) — It is the ratio of the rate of heat removal to the rate of energy input, in consistent units, for a complete refrigerating plant or some specific portion/part of that plant, under designated operating conditions. It is dimensionless value.

3.27 Compound Refrigeration Systems — A multi-stage refrigerating system in which a single charge of refrigerant circulates through all stages of compression (*see* multi-stage refrigerating system).

3.28 Combustible — A material that does not meet the definition of non-combustible material.

3.29 Coil — Part of the refrigerating system constructed from pipes or tubes suitably connected and serving as a heat exchanger (evaporator or condenser).

3.30 Condenser — A heat exchanger in which compressed refrigerant, to a suitable pressure, is condensed by the rejection of heat to an appropriate external cooling medium.

3.31 Condenser, Natural Draught Water-Cooled Condenser — A condenser that obtains cooling effect by the evaporation of water in natural air stream on the external surface of the tubes for the heat removal necessary to refrigerant vapour on the inside of the tubes. It is a condenser (without forced/induced air circulation) that is exposed to the atmosphere, cooled with water only.

3.32 Condenser, Evaporative — A condenser that obtains cooling effect by the evaporation of water in a forced/induced airstream on the external surface of the tubes for the heat removal necessary to liquify refrigerant vapour on the inside of the tubes. *See* also air-cooled condenser, double-pipe (tube-in-tube) condenser, desuperheater condenser, shell-and-tube condenser.

3.33 Condenser Water Cooled — It is a refrigerant condenser in which heat rejection is accomplished entirely by raising the temperature of the water used as cooling medium.

3.34 Condensing Unit— Combination of one or more compressors, condensers and or liquid receivers (when required) and the required accessories.

3.35 Condenser Coil — That part of a condenser constructed of pipe or tubing not enclosed in a pressure vessel.

3.36 Containers, Refrigerant — A pressurized cylinder for the storage of refrigerant.

3.37 Control — It is any manual or automatic device for regulation of a system or component on system in normal operation.

3.38 Controlled-Pressure Receiver — An intermediate pressure receiver used to flash-cool refrigerant and to control the feed pressure. Also known as inter stage open or closed flash cooler and economizer in case of screw compressors (*see* also pressure vessel).

3.39 Corrosion Allowance —An extra thickness added to the designed thickness of wall of pressure vessel or shell and tube heat exchanges. This acts as a safety factor against expected metal loss throughout the life span in equipment.

3.40 Critical Point — A point on the saturation curve where the refrigerant liquid and vapour states of a substance meet and become indistinguishable. They have identical volume, density, and enthalpy and there is no latent heat. The density, pressure, specific volume, and temperature at the critical point are referred to as the critical density, critical pressure, critical volume, and critical temperature respectively.

3.41 Design Pressure — The maximum pressure for which a specific part of a refrigerating system is designed.

3.42 Defrosting — It is the process of removing unwanted ice or frost from a cooling surface.

3.43 Dehumidification —It is the process of condensation of water vapour from air by cooling below dew point or by removal of water vapour from air by chemical or physical method.

3.44 Desuperheater — A device which provides sensible cooling to the refrigerant vapour.

3.45 Direct Expansion — Evaporator arrangement whereby liquid refrigerant is fed through an expansion valve or device and evaporates completely before leaving the evaporative as vapour.

3.46 Double-Pipe (Tube-in-Tube) Condenser/ Desuperheater — A type of condenser/desuperheater constructed of one or more assemblies of two tubes, one within the other, in which refrigerant vapour is condensed/desuperheated either in the annular space or the inner tube. *See* also air-cooled condenser, condenser, desuperheater, evaporative condenser, shell-and-tube condenser.

3.47 Downstream Pressure Regulator — A control valve which regulates the flow of oil or refrigerant gas or liquid through the device which is actuated toward open position by a pressure falling below regular or set point downstream of the valve.

3.48 Economizer — A vessel used in screw compressor installation to inject additional gas at intermediate pressure along the length of screw to get enhanced capacity.

3.49 Elevated Temperature Flame Limit (ETFL) — The minimum concentration of refrigerant hat is cap able of propagating a flame through a homogeneous mixture of the refrigerant and air. It is normally expressed as a refrigerant percentage by volume.

3.50 Engineering Control — The use of sensors, actuators, and other equipment to achieve a safe level of performance from a system or subsystem without aid of human interaction.

3.51 Equipment —An assembly, sub-assembly, accessory or component of a refrigeration system.

3.52 Equipment Enclosure — An enclosure designed to house refrigeration equipment and devices associated with a closed-circuit refrigeration system, or both, that is not intended for occupancy.

3.53 Evaporator — That part of a closed-circuit ammonia refrigerating system designed to vapourize liquid refrigerant to produce refrigeration (cooling effect).

3.54 Evaporator Coil —That part of an evaporator constructed of pipe or tubing not enclosed in a pressure vessel.

3.55 Extended Surface — It is heat transfer surface, one side of which is increased in area by addition of pins, discs, or other means.

3.56 Evaporator Pressure Regulator — A control valve which regulates the flow of primarily gaseous refrigerant from an evaporator section and which is actuated toward open by a pressure above set point upstream of the valve, maintains constant evaporator pressure irrespective of load function.

3.57 Exit — A passageway adjacent to the door through which people leave a building.

3.58 Fade Out Vessel — Vapour receiver connected to the low temperature side of a limited charge cascade system which is of sufficient size to limit the rise in pressure during system standstill.

3.59 Field Test — A test performed in the field to prove system tightness.

3.60 Forced Feed Oil Lubrication — A lubrication system in which oil is provided by an internal or external mechanical oil pump. This does not include splash type or drip type compressor lubrication systems.

3.61 Flammable Concentration Limit (FCL) — The refrigerant concentration limit, in air, determined in accordance with the standard and intended to reduce the risk of fire or explosion in normally occupied, enclosed spaces.

3.62 Flow Regulator — A control valve which regulates the flow of liquid through the device which is actuated by flow rate changes and pressure to maintain a predetermined flow rate irrespective of load fluctuations.

3.63 Heat Exchanger — Device designed to transfer heat between two physically separated fluids.

3.64 Header — A pipe or tube to which other pipes or tubes are connected.

3.65 Heat Pump — A refrigerating system used to transfer heat in to a space or substance.

3.66 High Pressure Side — The parts of a closed-circuit ammonia refrigerating system subjected to approximate condenser pressure.

3.67 High Side Float Valve — A control valve which regulates the flow of refrigerant or oil. This type of valve is actuated open by a rising liquid level upstream of the valve.

3.68 Hot Gas Bypass Regulator — A control valve which regulates the flow of refrigerant gas which is actuated toward open by a pressure falling below regulator set point downstream of the valve.

3.69 Immediately Dangerous to Life and Health (IDLH) — Maximum concentration from which unprotected persons are able to escape within 30 minutes without escape-impairing symptoms or irreversible health effects.

3.70 Indicating Device — An instrument that measures and registers certain operating conditions used for monitoring and control, such as temperatures and pressures, which can be read on a gauge, control display screen, or both.

3.71 Indirect Systems — A system in which a secondary coolant that is cooled or heated by the refrigeration system is circulated to the air or other substance to be cooled or heated.

3.72 Indirect-Closed System — A system in which a secondary coolant passes through a closed circuit in the air or other substance to be cooled or heated.

3.73 Indirect Open-Spray System — A system in which a secondary coolant is in direct contact with the air or other substance to be cooled or heated.

3.74 Informative Annex — An annex that is not part of the standard but is included for information purposes only.

3.75 Inside Dimension — Inside diameter, width, height or cross-sectional diagonal.

3.76 Internal Gross Volume — The volume as determined from internal dimensions of the container, with no allowance for the volume of the internal parts.

3.77 Joint-Mechanical — A gas tight connection obtained by joining metal parts with a positive-holding mechanical construction such as flanged, screwed or flared joints or compression fittings.

3.78 Knock Out Drum — A low pressure vessel installed before compressor to ensure compressor protection from accidental liquid refrigerant coming from evaporator/surge drum/accumulator.

3.79 Limited Charge System — A system in which, the internal volume and total refrigerant charge are such that, with the system idle, the allowable pressure is not exceeded when complete evaporation of the refrigerant liquid occurs.

3.80 Lower Flammability Limit (LFL) — The minimum concentration of the refrigerant that propagates a flame through a homogeneous mixture of refrigerant and air.

3.81 Low Side — The parts of a closed-circuit ammonia refrigerating system subjected to approximate evaporator pressure and/or the high stage suction (inter-stage) pressure of a two-stage system.

3.82 Low Side Float Valve — A control valve which regulates the flow of volatile liquid refrigerant into an evaporator. This type of valve is actuated by a rising liquid level downstream of the valve towards closed position.

3.83 Machinery — The refrigerating equipment forming a part of the refrigerating system including, but not limited to, any or all of the following: compressor, condenser, receiver, evaporator and connecting piping.

3.84 Machinery Room — A space or area that is designed specifically to safely house refrigerating equipment which includes, but is not limited to compressors, condensers, receivers, economizers, purgers, refrigerant pumps and other refrigeration related equipment.

3.85 Maximum Allowable Working Pressure (MAWP) — The maximum allowable working pressure permitted on a closed-circuit ammonia refrigerating system.

3.86 Mechanical Refrigerating System — *See* closed-circuit ammonia refrigerating system.

3.87 Multistage Refrigerating System — A refrigerating system in which compression of refrigerant is carried out in two or more steps.

3.88 Monitored — A means of continuous regulatory supervision, such as notification of staff, a third-party alarm service or a responsible party.

3.89 Normative Annex — An integral part of the mandatory requirements of the standard, which, for reasons of convenience, is placed after all other normative elements.

3.90 Non-combustible Material — A material which either does not burn itself or adds heat to a fire, when tested for non-combustibility in accordance with **5.3.5**.

3.91 Occupied Space — That portion of the premises accessible to or occupied by people, excluding machinery rooms.

3.92 Oil Pot — A vessel to collect oil at one place from one or all drain points for ease of draining.

3.93 Oil Separator — A device for separating oil and vapour from the refrigerant, usually installed in the compressor discharge line.

3.94 Over Feed Systems (Pumps Excess Liquid in the Evaporators) — It is the quantity of refrigerant supplied to evaporators greater than the minimum amount required to meet the cooling loads. The mixture of low temperature liquid and vapour leaves the evaporator and returns to a vessel designed to separate the liquid from vapour prior to vapour being compressed and the liquid again returns to evaporators.

3.95 Occupational Exposure Limit (OEL) — The time weighted average (TWA) concentration for a normal 8 h workday and 40 h work week to which nearly all workers can be repeatedly exposed without adverse effects.

3.96 Oxygen Deprivation Limit (ODL) — The concentration of a refrigerant or other gases that results in insufficient oxygen for normal breathing.

3.97 Packaged System — A fabricated and assembled self-contained closed-circuit refrigeration system, or a large portion thereof, either enclosed within its case or framework or unenclosed.

3.98 Parts Per Million (PPM) — Parts per million concentration in air.

3.99 Principal Machinery Room Door — An exterior door that has been designated as a primary emergency exit door for a machinery room.

3.100 Public Assembly Occupancy — A premises portion thereof where large numbers of people congregate and from which occupants cannot quickly vacate.

3.101 Saturation Pressure — The pressure at which vapour and liquid can exist in equilibrium at a given temperature.

3.102 Design Pressure — Pressure chosen for the strength calculation of each component. It is used for the necessary materials, thickness and construction for components with regard to their ability to withstand pressure.

3.103 Set Pressure — The pressure at which a pressure-relief device or pressure control is set to operate.

3.104 Test Pressure — The pressure to which a piece of equipment or a system is subjected, according to pressure test or leak test procedures.

3.105 Maximum Allowable Pressure — Maximum pressure for which the equipment is designed as specified by the manufacturer.

3.106 Strength Test Pressure (Hydraulic) — Pressure that is applied to test the strength of a refrigerating system or any part of it.

3.107 Ultimate Strength of a System — Pressure at which a part of the system ruptures or bursts.

3.108 Plate Heat Exchanger — Multiple corrugated plates arranged to form a discrete flow path within the boundary of the plates for each of the fluid media between which heat is transferred.

3.109 Positive Displacement Compressor — A compressor in which an increase in pressure is attained by changing (decrease) the internal volume of the compression chamber.

3.110 Pressure Imposing Element — Any device or portion of the equipment used to increase the refrigerant pressure.

3.111 Pressure Limiting Device — A pressure responsive mechanism designed to automatically stop the operation of the pressure imposing element at a predetermined pressure.

3.112 Pressure Relief Safety Devices — A pressure actuated valve or rupture member designed to automatically relieve excessive pressure.

3.112.1 *Pressure Relief Device* — A pressure actuated valve or rupture member designed to automatically relieve excessive pressure.

3.112.2 *Pressure Relief Valve* — A pressure actuated valve held closed by a spring or other means and designed to automatically relieve pressure in excess of its setting, also called a safety valve.

3.112.3 *Dual Pressure Relief Device* — Two pressure relief devices (valves or rupture members) mounted on a three-way valve that allows one device to remain active while the other is isolated.

3.112.4 *Pilot Operated Relief Valve* — A pressure-relief valve in which the major relieving device is combined with and is controlled by a self-actuated auxiliary pressure relief valve.

3.112.5 *Rupture Member* — A device that will rupture at a predetermined pressure differential.

3.112.6 *Changeover Device* — A valve controlling two safety devices and so arranged that only one can be made in operative at any one time.

3.113 Piping — The interconnecting parts of an ammonia closed-circuit ammonia refrigerating system which contain and convey the ammonia refrigerant. Piping includes pipe, flanges, bolting, gaskets, valves, fittings, the pressure-containing parts of other components, such as expansion joints, strainers, filters, and devices which serve such purposes as mixing, separating, snubbing, distributing, metering or controlling flow, pipe hangers, supporting fixtures and structural attachments.

3.114 Pressure Vessel — Any refrigerant containing receptacle part in a closed-circuit ammonia refrigerating system.

3.115 Restricted — Open to access by only authorized personnel and specifically excluding public access.

3.116 Proof Test — Design confirmation by testing a production sample to verify that it will not fail when exposed to a predetermined pressure that exceeds its rated design pressure.

3.117 Pump Down — It is the operation by which the refrigerant in a charged system is pumped down in to liquid receiver.

3.118 Pump Down Charge— The quantity of refrigerant stored at some point in the refrigeration system for operational, service, or stand by purposes.

3.119 Purging — It is the act of blowing out gas from a refrigerant containing vessel, usually for the purpose of removing non-condensable.

3.120 Readily Accessible — Capable of being reached safely and quickly for operation, repair, and inspection without requiring those to whom ready access is required to climb over or remove obstacles or to resort to the use of portable access equipment.

3.121 Receiver — A pressure vessel in a closed-circuit refrigerating system designed to hold the varying volume of liquid refrigerant resulting from changes in system operating conditions and to store the liquid refrigerant when the system is pumped down.

3.122 Refrigerant — Anhydrous Ammonia used for heat transfer in a closed-circuit ammonia refrigerating system used the vapour-compression cycle, which absorbs heat at a low temperature and low pressure of the fluid and rejects heat at a higher temperature and higher pressure of the fluid, usually involving change of state of the fluid.

3.123 Refrigerant-Pressure-Actuated Condenser Water Regulator — A device which regulates the flow of cooling water through a condenser and which is actuated towards open by high side pressure rising above the regulator set point.

3.124 Refrigerant Pump — A mechanical device for moving liquid ammonia refrigerant within a closed-circuit ammonia refrigerating system.

3.125 Refrigerant Concentration Limit (RCL) — The refrigerant concentration limit in the air determined in accordance with IS 16678 (Part 1)/ISO 5149-1 intended to reduce the risks of acute toxicity, asphyxiation, and flammability hazards in normally occupied enclosed spaces.

3.126 Refrigerant Detector — A device that is capable of sensing the presence of ammonia refrigerant vapour.

3.127 Self-contained — Having all essential equipment, piping and devices to form a complete closed-circuit mechanical refrigeration system, except energy and control connections, and contained in a case or framework.

3.128 System — A set of components working together as a mechanism or interconnected network.

3.129 Sealed System — Refrigerating system in which all refrigerant containing components are made tight by welding, or a similar permanent connection.

3.130 Self-Contained System — Complete factory-made and tested closed-circuit refrigerating system in a suitable frame or enclosure, that is fabricated and transported complete in one or more sections and which has no refrigerant-containing parts that are connected on site by other than companion or block valves.

3.131 Shall (shall not) — Term used where the provision is mandatory.

3.132 Shell and Tube Condenser — A type of condenser with tubes secured into a tube sheet at one or both ends of an enclosing shell.

3.133 Shell and Tube Evaporator — A type of evaporator where tube screen closed in a shell. Refrigerant can be either in the shell or tubes.

3.134 Secondary Coolant — Any liquid used for the transmission of heat without vaporization.

3.135 Should (should not) — Term used where the provisions are not mandatory but are (are not) recommended good practice under most but not all conditions.

3.136 Strainer — Pressure-containing component through which fluid flows for the purpose of separating contaminants from the flow stream.

3.137 Sub-Cooled — Reduced to a temperature below the saturation temperature for the existing pressure.

3.138 Super Heat — Additional sensible heat content in a vapour which raises the temperature of the vapour above the saturation temperature corresponding to its pressure.

3.139 Surge Drum — A receiver installed on the low-pressure side of a refrigeration system that is close-coupled to one or more evaporators and provides liquid feed and a liquid-from-vapor disengaugement space to ensure that dry vapour is returned to the compressor.

3.140 System Flooded — A system in which only part of the refrigerant passing over the heat transfer surface is evaporated, and the portion not evaporated is separated from vapour and is recirculated.

3.141 Thermostat — An automatic control device actuated by temperature and designed to be responsive to temperature.

3.142 Threshold Limit Value Time Weighted Average (TLV-TWA) — The refrigerant concentration in air for a normal 8 h work day and a 40 h work week to which repeated exposure, day after day, will not cause an adverse effect in most persons.

3.143 Toxicity — The ability of a refrigerant to be harmful or lethal due to acute or chronic exposure by contact, inhalation, or ingestion, temporary discomfort at a level that is not impairing is excluded.

3.144 Trained Technician — An individual having adequate training and experience which qualify that individual to service, maintain and operate a closed-circuit ammonia refrigerating system according to written procedures.

3.145 Tight Construction — Solid construction with holes or openings that are either sealed or provided with tight- fitting doors to control the transfer of liquid, moisture, air and vapour.

3.146 Tight-Fitting Door — A tightly constructed door with seals to minimize gap clearances between the entire door perimeter and its fixed door frame, which is intended to control the transfer of liquid, moisture, air and vapour.

3.147 Trained Operator — An individual having training and experience, which qualify that individual to service, maintain and operate and perform basic system inspections on a closed-circuit refrigeration system with which he or she has become familiar or in accordance with written procedures.

3.148 Valve — A pressure-containing component that stops, permits, or controls flow. *See* also piping, automatic expansion valve, automatic liquid refrigerant drain valve, check valve, control valve, downstream pressure regulator, dual pressure-relief device, evaporator pressure regulator, flow regulator, high side float valve, hot gas bypass regulator, low side float valve, motorized valve, oil drain float valve, pressure-relief device, pressure-relief valve, refrigerant-pressure-actuated condenser water regulator, self-closing valve, shutoff valve, solenoid valve, thermostatic expansion valve, three-way valve, motorized valve either electrically or pneumatically actuated.

3.149 Valve-Four Way — Valve used to reverse refrigerant flow direction, used for reverse cycle defrost.

3.150 Valve Charging — A valve used to charge or add refrigerant to the system or add oil to the compressor crankcase.

3.151 Check Valve — It is a valve allowing fluid flow in one direction only.

3.152 Float Valve — Refrigerating valve controlled by liquid level and valve actuated by float in a liquid container.

3.153 Purge Valve — A device to allow fluid to flow out of system, particularly non-condensable gases

3.154 Balanced Relief Valve — A pressure relief valve that incorporates means of minimizing the effect of back pressure on the operational characteristics of the valve (operating pressure, closing pressure, and relieving pressure).

3.155 Control Valve — A control valve is a valve used to control fluid flow by varying the size of the flow passage as directed by a control signal.

3.156 Motorized Valve — A valve operated by a motor.

3.157 Oil Drain Float Valve — *See* high side float valve, except controlling oil.

3.158 Over Flow Valve — Pressure relief device discharging to the low pressure side of the refrigerating system.

3.159 Pressure Regulator (Differential Pressure Regulating) Valve — An automatic valve that is responsive to difference between its own inlet and outlet or any other pressure and functions to throttle the fluid flow when necessary to prevent the set pressure from falling or rising from a selected value.

3.160 Pressure Regulator (Back/Inlet Pressure Regulating) Valve — An automatic valve that is responsive to its own inlet pressure and functions to throttle the fluid flow when necessary to prevent the set pressure from falling below a selected value.

3.161 Pressure Regulator (Outlet Pressure Regulating) Valve — An automatic valve that is responsive to its own outlet pressure and functions to throttle the fluid flow when necessary to prevent the set pressure from rising a selected value.

3.162 Pilot–Operated Relief Valve — A pressure-relief valve in which the major relieving device is combined with and is controlled by a self-actuated auxiliary pressure relief valve.

3.163 Self-Closing Valve — A manually-operated stop valve that will automatically return to the closed position by means of (a spring or by weight, or by quick closing ball) other device when the operating handle is released.

3.164 Shut-Off Valve — Externally actuated valve solely designed to stop flow for the purpose of isolating a sub-section of the system, also referred to in practice as, but not limited to – 'block', 'hand', 'service', 'stop', or 'ball' valve.

3.165 Solenoid Valve — Control valve actuated by an electrically charged coil, designed to functionally stop/start flow.

3.166 Thermostatic Expansion Valve — A control valve which regulates the flow of refrigerant into an evaporator of a closed-circuit ammonia refrigerating system and which is actuated by changes in evaporator pressure and superheat of the refrigerant gas leaving the evaporator. The basic function is to control the amount of super heat.

3.167 Three Way Valve — A manually operated valve with one inlet which alternately can stop flow to either of two outlets. A service valve for dual mounted pressure relief valves.

3.168 Welded Joint — Permanently sealed joint, created by the joining of metal parts in a molten state.

SECTION 2: DESIGN AND INSTALLATION CONSIDERATIONS AFFECTING CONSTRUCTION

4 LOCATION OF AMMONIA REFRIGERATION MACHINERY

4.1 General

The location of ammonia refrigeration machinery shall comply with this clause. Ammonia refrigeration machinery located in a machinery room complying with **6** or located outdoors in accordance with **4.2.2** shall be permitted in conjunction with a secondary coolant that serves any occupancy in accordance with **5.2.5**.

4.2 Permissible Equipment Locations

Ammonia refrigeration machinery shall be located in a machinery room complying with **6** unless otherwise permitted by the standard.

4.2.1 *Listed Equipment*

Listed equipment containing not more than 3 kg of ammonia and installed in accordance with the listing and the manufacturer's instructions shall be permitted in any occupancy area without a machinery room.

4.2.2 *Outdoor Installations*

Ammonia refrigeration machinery shall be permitted to be installed outdoors. Ammonia refrigeration machinery, other than piping, installed outdoors shall be located not less than 6.5 m from building openings, except for openings to a machinery room or openings to an industrial occupancy complying with **7.2**.

4.2.3 *Industrial Occupancies*

The following ammonia refrigeration machinery shall be permitted to be installed outside of a machinery room in industrial occupancies complying with **7**:

a) Evaporators used for refrigeration or dehumidification;
b) Low-probability pumps;
c) Condensers;
d) Valves, including but not limited to control and pressure-relief valves, and connecting piping, any of which are associated with items a), b), c), and d); and
e) An ammonia refrigeration system or portions thereof with a total connected compressor drive power not exceeding 74.6 kW.

4.2.4 *Public Assembly, Commercial and Large Mercantile Occupancies*

Where approved, ammonia refrigeration machinery shall be permitted outside of a machinery room for applications other than human comfort in a public assembly occupancy, commercial occupancy or large mercantile occupancy.

The quantity of ammonia shall be limited such that a complete discharge from any independent refrigerant circuit will not result in an ammonia concentration exceeding 300 ppm (IDLH) in any room or area where equipment containing ammonia is located.

5 GENERAL SYSTEM DESIGN REQUIREMENTS

This clause applies to general design requirements for closed-circuit mechanical refrigeration system.

5.1 General Design Requirements

5.1.1 *Refrigerant-Grade Anhydrous Ammonia Specifications*

Refrigeration grade anhydrous ammonia that meets or exceeds the minimum requirements of IS 662 shall be used for the initial charge and subsequent top-up (fill the system to the operating intended inventory) of all ammonia refrigerating systems.

5.1.1.1 A grade specifying less than 99.95 percent ammonia shall not be used.

5.1.1.2 Purity requirements are shown in the Table 1.

Table 1 Purity Requirements

(*Clause* 5.1.1.2)

Sl No. (1)	Characteristic (2)	Purity Requirements (3)
i)	Ammonia content	99.95 percent, *Min*
ii)	Non-basic gas in vapour phase	25 ppm, *Max*
iii)	Non-basic gas in liquid phase	10 ppm, *Max*
iv)	Water	33 ppm, *Max*
v)	Oil (as soluble in petroleum ether)	2 ppm, *Max*
vi)	Salt (calculated as NaCl)	None
vii)	Pyridine, hydrogen sulphide, Naphthalene	None

5.1.1.3 *See* Annex K for additional information regarding the characteristics and properties of ammonia.

5.1.1.4 *See* Annex D for information regarding stress corrosion cracking with anhydrous ammonia.

5.2 Volume Calculation for Determining Concentration of an Ammonia Release

For the purpose of applying **4.2.4** the volume used to calculate the potential ammonia concentration in the event of a release shall comply with this clause. The volume used to calculate the potential ammonia concentration shall be the gross volume of a room or space into which the ammonia is expected to be relesed.

The following equation can be used to demonstrate that the ammonia concentrations would never exceed 40 000 ppm:

$$C = G \times (\text{vapour specific volume}) \times (100\ \%)/V$$

where

C = Volumetric concentration of ammonia in %;

G = Amount of ammonia released, kg;

V = Room volume, m^3; and

Vapour specific volume = Vapour specific volume for on hydrous ammonia, m^3/kg.

5.2.1 *Wall Opening*

Where spaces adjacent to those containing refrigeration systems, equipment or portions thereof are connected by permanent wall openings, the volume of such adjacent spaces shall not contribute to the calculated volume used for ammonia release concentration calculations unless, based on the size and elevation of permanent wall openings or a mechanical ventilation system, the designer determines that migration and dilution or a release over the combined spaces will occur. The volume shall be the combined space, provided that the openings or mechanical ventilation are clearly identified as the basis for the design analysis.

5.2.2 *Space above Suspended Ceilings*

The space above a suspended ceiling shall not be included in the volume calculation unless the space above the ceiling functions as a part of the air distribution system.

5.2.3 *Interconnected Floor Levels and Mezzanines*

Where a refrigeration system, or portion thereof, is located in a room or space containing multiple floor levels connected through an open atrium or where there is a mezzanine open to a room or space, the combined volume of interconnected floors and mezzanines is permitted in the volume calculation.

5.2.4 *Mechanical Ventilation Considerations*

Where a refrigeration system, or portion thereof, is located in an area served by a mechanical ventilation system which also serves additional spaces, within an air handler, or in an air distribution duct system, the volume of the rooms or spaces connected by the ventilation or duct system, including the volume of the connected supply and return air ducts exterior to the room and any connecting plenum, shall be used.

NOTE — The following exception shall be noted:

The smaller of the volumes on either side of a damper shall be used where portions of the ventilation or duct system are subject to being isolated by dampers, other than:

a) Fire dampers;
b) Smoke dampers;
c) Combination fire and smoke dampers; or
d) Dampers that continuously maintain not less than 10 percent airflow.

5.2.5 *Use of Ammonia Refrigeration with Secondary Coolants*

Ammonia refrigeration machinery located in a machinery room complying with **6** or outdoors in accordance with **4.2.2,** shall be permitted to be used in conjunction with a secondary coolant that serves any occupancy, provided that the system is one of the following types and that use the secondary coolant:

a) Indirect closed system; and
b) Double-indirect open-spray system.

5.2.6 *Vacuum*

Refrigeration equipment shall be designed for a vacuum of 98 kPa (737 mm of mercury).

5.2.7 *Minimum Design Pressure*

The minimum ammonia design pressures stipulated for various types of equipments are listed in Table 2. However, the maximum allowable pressure shall be determined by taking into account the following factors:

a) The maximum ambient temperature;
b) The possible presence of non-condensable gases;
c) The setting of any pressure relief device;
d) The method of defrosting;
e) The application (for example, cooling or heating application);
f) Solar radiation (for example, impact on receiver exposed to direct solar radiation); and
g) Fouling.

Note that the maximum working pressure of particular systems may require higher design pressures and the strength and leak test pressure will be accordingly higher.

The design pressure shall not be less than the pressure arising under all operating, shipping, and standby conditions.

When selecting the maximum allowable working pressure (MAWP) and the minimum/maximum design metal temperature (MDMT), suitable allowance shall be provided for setting pressure-limiting devices to avoid nuisance shutdowns and loss of refrigerant at maximum operating conditions.

The pressure data in Table 2 shall not be used in lieu of the stipulated minimum design pressures for the various types of equipment specified in the Equipment sections of this standard.

5.2.8 *System Design Temperature*

5.2.8.1 All components of the closed-circuit ammonia refrigerating system shall be designed to meet the requirements of the minimum and maximum system design temperatures. For details refer to ISO 13971.

The following exceptions and note pertain to the minimum design pressure list of equipment:

a) Low side system components designed for 1 034 kPa and high side components designed for 1 720 kPa are acceptable if they are suitably protected with relief valves;
b) Minimum low side design pressure for reciprocating compressors shall be 1 720 kPa gauge (17.2 bar gauge);
c) Minimum high-side design pressure shall be the greater of:
    1) 1 720 kPa gauge (17.2 bar gauge) where hot gas defrost is utilized or hot gas pressure may be applied to the evaporator;
    2) The high side hot gas source design pressure where hot gas defrosts is utilized or hot gas pressure may be applied to the evaporator; and
    3) The design saturation pressure corresponding to the highest expected refrigerant evaporating temperature.
d) When ammonia liquid or oil is to be transferred from pressure vessels by pressurized ammonia gas, the pressure vessel design pressure shall accommodate the maximum possible transfer pressure and take into account the lowest possible coincident metal temperature;
e) Application design pressure which exceeds these minima shall prevail;
f) Valves are permitted within the design pressure-temperature envelope. For temperature please refer ISO 13971;
g) For controls designed specifically for and usable for low side use exclusively, minimum design pressure shall be 1 720 kPa gauge (17.2 bar gauge). Obtain the MAWP from the controls manufacturer and their final testing requirements under applicable code;
h) Other types and styles of evaporators may be utilized within a closed-circuit ammonia mechanical refrigeration system. When types and styles of evaporators which are not listed are utilized, consult the equipment manufacturer to determine the minimum design pressure rating.

NOTE — When high pressure/high temperature heating applications (that is, heat recovery/heat pumps) using ammonia within a closed-circuit ammonia mechanical refrigeration system which are not listed above are to be used, consult with the equipment manufacturer to determine the minimum design pressure rating.

Table 2 Minimum Design Pressure

(*Clause* 5.2.7)

Sl No.	Types of Equipment	Minimum Design Pressure	
		(bar gauge), Rounded off	kPa (g)
(1)	(2)	(3)	(4)
i)	Compressors: High-stage with water-cooled or evaporative condensing	21	2 070
ii)	High-stage with air-cooled condensing	27	2 760
iii)	Booster and reciprocating	21	2 070
iv)	Air-cooled condensers and air-cooled desuperheater	27	2 760
v)	Evaporative condensers	21	2 070
vi)	Atmospheric/natural draft condenser	21	2 070
vii)	Shell-and-tube condensers and double-pipe condensers	21	2 070
viii)	Plate heat exchanger condensers	21	2 070
ix)	Forced air evaporator coils	17	1 720
x)	Shell-and-tube evaporators (refrigerant in shell)	17	1 720
xi)	Shell-and-tube evaporators (refrigerant in tubes)	17	1 720
xii)	Plate heat exchanger evaporators	17	1 720
xiii)	Water/brine immersed evaporator coils (refrigerant in tubes) for example, block ice plant coils, Ice bank tank coils	17	1 720
xiv)	Natural draft evaporator coil pressure vessels:	17	1 720
xv)	High side service utilizing water-cooled or evaporative condensing	21	2 070
xvi)	High side service utilizing air-cooled condensing	27	2 760
xvii)	Low side service	17	1 720
xviii)	Refrigerant pumps-refrigerant pressure containment envelope:	21	2 070
xix)	High side service utilizing water-cooled or evaporative condensing	27	2 760
xx)	High side service utilizing air-cooled condensing low side service	17	1 720
xxi)	Refrigerant valves at fluid and operating temperatures of –30°C to + 116°C	21	2 070
xxii)	Controls	21	2 070
xxiii)	Receiver: High pressure receiver for example, storage receiver, oil separator, oil pot, priority vessels,	21	2 070
xxiv)	Intermediate pressure receiver: for example, intermediate cooler (open/closed), economizer	17	1 720
xxv)	Low pressure receiver : for example, recirculator/pump circulation vessel, surge drum, accumulator, knockout drum, slop pots	17	1 720
xxvi)	Piping, tubing, fitting		
	High side	21	2 070
	Low side	17	1 720

5.3 Materials

5.3.1 *General*

5.3.1.1 All materials used in the construction of the equipment as described from **6** to **12** shall be suitable for ammonia refrigerant at the working temperature and pressure to which component shall be subjected.

5.3.1.2 No materials shall be used that will deteriorate because of the presence of ammonia refrigerant, lubricating oil, or a combination of both or any normal contaminant such as air or water.

5.3.1.3 All refrigeration system components shall be installed in locations to mitigate from external damage and include guarding or barricading as necessary.

5.3.1.4 All moving or rotating components shall have appropriate guarding.

5.3.1.5 Refrigerant shall be stored only in approved designed cylinders or vessels.

5.3.1.6 Used equipment to be installed in a new design/project shall meet the minimum safety requirements of this standard.

5.3.2 *Metallic Materials*

Cast iron and malleable iron shall only be used when suitable for the particular application in accordance with the requirements of IS 16678 (Part 2)/ISO 5149-2. Cast iron, malleable iron, nodular iron, steel, cast steel, and alloy steel may be used as specified in IS 16678 (Part 2)/ISO 5149-2, ISO 5922 for malleable cast iron, ISO 3755 for cast steel, and ISO 14737 for carbon and alloy steels.

5.3.2.1 Zinc, copper, and copper alloys shall not be used in contact with or for containment of ammonia. Copper-containing anti-seize and/or lubricating compounds shall not be used in contact with ammonia piping. Copper as a component of brass alloys may be used for bearings or other non-refrigerant-containment uses.

5.3.2.2 Other metallic materials, such as aluminum, aluminum alloys, lead, tin, and lead-tin alloys may be used if they conform to **5.3.1**. Where tin and tin-lead alloys are used, the alloy composition shall be suitable for the temperatures of application.

5.3.3 *Non-metallic Materials*

5.3.3.1 Non-metallic materials may be used if they conform to **5.3.1**.

Following is the ready reference for the materials to be used for various items used in closed-circuit ammonia systems:

a) The requirement of equipment vessel is as follows:

Sl No. (1)	*Service* (2)	*Material* (3)	*Specification* (4)
i)	HP receiver, oil separator, LP accumulator, Oil rectifiers, Oil collection vessels, and Tanks, (up to – 20°C application)	Steel plates	IS 2002 Grade 2/IS 2041 Grade R260
ii)	LP accumulator, oil vessels, etc. for below – 20°C application	Steel plates	IS 2041 Grade R260

b) Valves

Manually operated valves shall be of following types:

Sl No. (1)	*Service* (2)	*Type* (3)	*Material* (4)	*Specification* (5)
i)	Refrigerant	All types (for example isolating valves, check valves, control valves)	Steel or Stainless steel	ISO 21922
ii)	Cooling water:	Butterfly valve	Cast iron, Cast steel	
	over 75 mm 50 mm and below	Ball valve		IS 778 IS 1703
iii)	Water supply, bleeds, and drain	Ball valve, Butterfly valve Swing check	Cast steel	IS 778
	Chilled water– supply and return lines			IS 778
iv)	Defrost water – supply and return	Ball valve	Cast steel	IS 778

NOTE — All water line valves above 50 mm shall be of flanged construction. All water valves of 50 mm and below shall be ball valves with cast steel body, SS working parts, 3 section type, and weldable end type.

c) Piping materials guideline

Sl No. (1)	*Service* (2)	*Material* (3)	*Specification* (4)
i)	Refrigerant, including oil, purger, vent, line (above –20°C)	Steel pipe (seamless)	Heavy duty high quality carbon steel pipe as per Table 5
ii)	Refrigerant piping (for –20°C and below)	Steel pipe (seamless)	–
iii)	Evaporative condenser tube	Steel pipes or S.S.304 L	–
iv)	Water circulating pipelines/chilled water lines (up to 150 NB)	Galvanized steel (ERW) medium duty class M	IS 1239 (Part 1) or IS 1239 (Part 2) [heavy duty/class H]
v)	Water circulating pipelines/chilled water lines (up to 200 NB and higher)	Galvanized steel (ERW) medium duty class M	IS 3589 – ERW, heavy duty/ class H
vi)	Make up water supply, bleeds, drains, defrosting water, etc	Galvanized steel (ERW) medium duty class M	IS 1239 (Part 1) or IS 1239 (Part 2) or IS 3589, [medium duty/class M]

5.3.4 *Heat Exchanger Tube Specifications*

Tubes shall be made by automatic welding process or seamless process or shall be either hot finished or cold drawn. For welded tubes, the tubes shall be made from flat-rolled steel by an automatic welding process with no addition of filler metal. Seamless tubes may be supplied either in hot finished or cold drawn condition at the manufacturer's option, unless otherwise specified by the purchaser. Cold drawn tubes shall be suitably heat-treated. It shall be as per IS 11714 (Part 1 to 5) with following exception:

The chemical composition of tube shall be C 0.06-0.18, S $\leq$ 0.035, Mn 0.27-0.63, Si $\leq$ 0.25, P $\leq$ 0.035. It shall have a yield strength (MPa) of $\geq$ 180, the tensile strength (MPa) of $\geq$ 325 and has elongation percentage of $\geq$ 35.

5.3.5 *Test for Non-Combustibility*

Material can be tested for combustibility as given below;

a) A fire test method whereby a 1-1/2 by 1-1/2 by 2 in high test specimen is inserted within a 3 inch diameter refractory tube preheated to 750°C. The specimen is left in the chamber for a maximum of 30 min. The test material is to be considered as non-combustible when at least three of the four test specimens conform to the following criteria:

b) When the weight loss of the specimen is 50 percent or less, the recorded temperature of the surface and interior thermocouples shall not at any time during the test rise more than 30°C above the furnace temperature at the beginning of the test and there shall be no flaming from the specimen after the first 30 s.

c) When the weight loss of the specimen exceeds 50 percent, the recorded temperature of the surface and interior thermocouples shall not at any time during the test rise above the furnace temperature at the beginning of the test and there shall be no flaming from the specimen.

5.4 Purging

Means shall be provided to separate, collect, and remove air and other non-condensable gases from the refrigeration system. Non-condensable gases may be purged to atmosphere through water or vented to atmosphere. For detail refer **15.4.1**.

5.5 Oil Removal

Provisions in design shall be made for removing oil from piping and equipment where oil is likely to collect the following:

a) A rigid-piped oil return or transfer system;

b) A vessel equipment with a shut-off valve in series with a self-closing shut-off valve; and

c) A valve and piping assembly at the draining point where oil is removed from the system. At a minimum, a shut-off valve in series with a self-closing shut-off valve is required.

5.5.1 *Temporary Piping*

Where draining of oil requires the use of temporarily attached rigid piping, such piping shall be supported and shall have tight connections.

5.5.2 Detailed operating procedures suitable for each drain point shall be provided for oil draining operations. Safety and personal protective equipment shall be specified.

5.5.3 Oil draining shall be conducted only by a trained technician(s). The oil draining process shall not be left unattended by the trained technician(s) while in progress.

NOTE — Permanently piped automatic oil drain return systems shall be taken as an exception.

5.6 Insulation/Supports

5.6.1 Equipment with cold surfaces, not intended for heat exchange, shall be properly insulated to prevent or control condensation. *See* **5.9** condensation control regarding piping and fittings.

NOTE — Valve groups or equipment with cold surfaces are permitted to be left un-insulated to accommodate access for service, provided the vapor retarder is sealed to the piping or equipment.

5.6.2 Hot discharge lines less than 2.3 m high and those near passageways, aisles, or walkover stairs and landings (that is, on roofs) shall be suitably guarded or insulated to reduce surface temperatures to tolerable limits or be unreachable by design from personnel using the path of travel.

5.7 Foundations, Piping, Tubing, and Equipment Supports

5.7.1 Supports and foundations shall be adequate to prevent excessive vibration and movement of the piping, tubing, and equipment.

5.7.2 Supports shall meet or exceed the manufacturer's recommendations.

5.7.3 Supports and anchorage for refrigeration equipment shall be designed in accordance with SP 7.

5.7.4 Structural supports shall be non-combustible. Base supports (for example, roof "sleepers", shims) for piping or equipment may be pressure treated lumber.

Please refer IS 8910/ISO 404.

Specifications – Fe 67.47-74.85 percent, Cr 17-19 percent, Ni 8-10 percent, S 0.15-0.35 percent, P 0.06 percent, Mn 0-2 percent, C 0-0.12 percent.

Density 7.7kg/dm^3, specific heat at 20°C 460 J/kg.K.

5.7.5 *Recommended Material*

a) Liquid, vapour, discharge and hot gas lines carbon steel pipe must be as per Table 3; and

b) All threaded pipe carbon steel will be as per Table 4. Threaded joints are allowed only up to 40 NB.

NOTE — Metal temperatures between –29°C and –101°C provided the maximum circumferential or longitudinal tensile stress resulting from coincident pressure, thermal contraction or bending between supports does not exceed 35 percent of allowable stress for the material mentioned above.

Table 3 Seamless Carbon Steel Pipe Data for Weld Joints

(*Clauses* 5.7.5 and H-1)

Sl No. (1)	Pipe Nominal Size in mm (2)	Wall Thickness in mm (3)	Pipe ID in mm (4)	Pipe OD in mm (5)	Pipe Weight in kg/m (6)
i)	15	3.73	13.84	21.30	1.620
ii)	20	3.91	18.88	26.70	2.200
iii)	25	4.55	24.3	33.40	3.240
iv)	32	4.85	32.5	42.20	4.470
v)	40	5.08	38.14	48.30	5.410
vi)	50	3.91	52.48	60.30	5.440
vii)	65	5.16	62.68	73.00	8.630
viii)	80	5.49	77.92	88.90	11.290
ix)	100	6.02	102.26	114.30	16.080
x)	125	6.55	128.2	141.30	21.770
xi)	150	7.11	154.08	168.30	28.260
xii)	200	8.18	202.74	219.10	42.550
xiii)	250	9.27	254.46	273.00	60.290
xiv)	300	10.31	303.18	323.80	79.710
xv)	350	11.13	333.34	355.60	94.550

Table 4 Seamless Carbon Steel Pipe Data for Threaded Joints

(*Clauses* 5.7.5, 13, 13.1, 13.2.2 *and* H-1)

Sl No. (1)	Pipe Nominal Size in mm (2)	Wall Thickness in mm (3)	Pipe ID in mm (4)	Pipe OD in mm (5)	Pipe Weight in kg/m (6)
i)	15	3.73	13.8	21.3	1.62
ii)	20	3.91	18.9	26.7	2.2
iii)	25	4.55	24.3	33.4	3.24
iv)	32	4.85	32.5	42.2	4.47
v)	40	5.08	38.1	48.3	5.41

Table 5 Seamless Stainless Steel Pipe Data for Weld Joints

(*Clauses* 5.3.3.1, 13.2.1, 13.5.2.5 *and* H-1)

Sl No. (1)	Pipe Nominal Size in mm (2)	Wall thickness in mm (3)	Pipe ID in mm (4)	Pipe OD in mm (5)	Pipe Weight in kg/m (6)
i)	15	2.770	15.76	21.3	1.270
ii)	20	2.870	20.96	26.7	1.680
iii)	25	3.380	26.64	33.4	2.500
iv)	32	3.560	35.08	42.2	3.380
v)	40	3.680	40.94	48.3	4.050
vi)	50	2.770	54.76	60.3	3.930
vii)	65	3.050	66.9	73.0	5.260
viii)	80	3.050	82.8	88.9	6.450
ix)	100	3.050	108.2	114.3	8.360
x)	125	3.400	134.5	141.3	11.570
xi)	150	3.400	161.5	168.3	13.840
xii)	200	3.760	211.58	219.1	19.960
xiii)	250	4.190	264.72	273.1	27.780
xiv)	300	4.570	314.76	323.9	36.000
xv)	350	4.780	346.04	355.6	41.300

Table 6 Seamless Stainless Steel Pipe Data for Threaded Joints

(*Clause* H-1)

Sl No. (1)	Pipe Nominal Size in mm (2)	Wall Thickness in mm (3)	Pipe ID mm (4)	Pipe OD mm (5)	Pipe Weight kg/m (6)
i)	15	3.75	13.8	21.3	1.62
ii)	20	3.91	18.9	26.7	2.2
iii)	25	4.55	24.3	33.4	3.24
iv)	32	4.85	32.5	42.2	4.47
v)	40	5.08	38.1	48.3	5.41

Table 7 Maximum Allowable Hanger Rod Spacing

(*Clause* 5.7.5 *and* 13.2.1)

Sl No. (1)	NPS Diameter mm (2)	Maximum Span m (3)	Minimum Rod Diameter mm (4)
i)	25.40	2.13	9.53
ii)	31.75	2.74	9.53
iii)	50.80	3.05	9.53
iv)	63.50	3.35	12.70
v)	76.20	3.66	12.70
vi)	101.60	4.27	15.88
vii)	127.00	4.88	15.88
viii)	152.40	5.18	19.05
ix)	203.20	5.79	22.23
x)	254.00	6.71	22.23
xi)	304.80	7.01	22.23
xii)	355.60	7.62	25.40
xiii)	406.40	8.23	25.40
xiv)	457.20	8.54	31.75
xv)	508.00	9.15	31.75

5.7.6 Seismic restraints shall be provided as per **4.3.5** of Part 8, Section 3 of SP 7.

5.8 Service Provision

5.8.1 All serviceable components of a closed-circuit ammonia refrigerating system shall be provided with safe access, which can be permanent or portable, for maintenance and inspection. An unobstructed readily accessible opening and passageway not less than 0. 914 m in width and 2.21 m in height shall be provided for equipment and components of the system requiring routine maintenance.

The following exceptions shall be noted:

a) Refrigerant evaporators that are suspended overhead and require routine maintenance shall be permitted to use portable means of access; and
b) Air filters, brine control or stop valves, fan motors or drives, and remotely de-energized electrical connections shall be permitted to be provided access by an unobstructed space not less than 762 mm in depth, width, and height. Where an access opening is immediately adjacent to these items and the equipment is capable of being serviced, repaired, and replaced from this opening, the dimensions shall be permitted to be reduced to 559 mm by 762 mm provided the largest piece of equipment can be removed through the opening.

5.8.2 Access to refrigerating system connections located outdoors shall be limited to authorized personnel only.

5.8.3 Design provisions for maintenance and functional testing of controls shall be provided.

5.8.4 When a pressure gauge is permanently installed on the high side of the refrigeration system, its dial shall be graduated to be at least 1.2 times (120 percent) the design pressure.

5.9 Condensation Control

5.9.1 Piping and fittings that convey brine, refrigerant, or coolants that during normal operation could reach a surface temperature below the dew point of the surrounding air and that are located in spaces or areas where condensation could cause a hazard to the building occupants or damage to the structure or electrical or other equipment shall be properly insulated (*see* **5.5**) or treated to mitigate such an occurrence.

Every refrigerant-containing component shall be factory tested and proven tight by the manufacturer at not less than the design pressure for which it is rated.

5.9.2 *Ultimate Strength Requirements*

5.9.2.1 Every component which are subject to pressure during operation of close circuit ammonia refrigeration system, such as valves, pumps, and controls mechanism shall be listed individually. They shall be designed constructed and assembled to have an ultimate strength sufficient to withstand three times the design pressure for which it is rated. This shall however exclude the following:

Compressors, pressure vessels (including piping interconnecting evaporator), condensers and heating coils with refrigerant as working fluids.

5.9.2.2 Components exempted from the requirement of **5.9.2.1** shall comply with additional requirements listed in this standard and IS 2002 or IS 2041 where applicable.

5.9.2.3 Secondary coolant sides of components other than those specified in IS 2002 or IS 2041, shall be designed, constructed and assembled to have ultimate strength sufficient to withstand 1 720 kPa gauge or two times the design pressure for which they are rated, whichever is greater.

5.10 Signage and Nameplates

5.10.1 *Machinery Room Signage*

5.10.1.1 *See* **5.10.5** pipe markings and **5.10.6** equipment labels.

5.10.1.2 *See* Annex F (*informative*), machine room signs.

5.10.1.3 *See* **6.13.4** and **6.15** for alarm signage.

5.10.2 *Emergency Shutdown Signage*

It shall be the duty of the person in charge of the premises on which the closed-circuit ammonia refrigerating system is installed to provide a schematic drawing or panel giving directions for the emergency shutdown of the system at a location that is convenient to access by the trained refrigeration system staff and trained emergency responder personnel familiar with the system.

When a refrigerating machinery room is used, the emergency procedures shall be posted outside and immediately adjacent to or on each principal door.

Schematic drawing(s) or signage shall include the following:

a) Instructions (details/steps) for shutting down the system in case of emergency;
b) The name and contact telephone numbers of the refrigeration operating, maintenance and management staff, emergency responders, and safety personnel;
c) The names and telephone numbers of all corporate, local, state, and central agencies to be contacted as required in the event of a reportable incident;
d) Type and quantity of refrigerant(s) in the system(s); and
e) Field test pressures applied.

5.10.3 *Wind Indicator*

5.10.3.1 When a wind indicator (sock or pennant) is installed, it shall be suitable for the environment and mounted where it is readily visible for use as incorporated into the facility emergency action and response plan shall comply with schedule 3 of *Chemical Accidents* (*Emergency Planning, Preparedness and Response*) *Rules,* 1996 issued by Ministry of Environment, Forest and Climate Change.

5.10.4 *Valve Tagging*

Valves required for system emergency shutdown procedure(s) shall be clearly identified on a readily available diagram and shall be updated when changes are made to the system. These valves shall also be uniquely identified (example, tags, signs, etc) on the actual system.

5.10.5 *Pipe Marking*

All piping mains, headers and branches shall be identified as to the physical state of the refrigerant (vapour, liquid, or both), the relative pressure level of the refrigerant, and the direction of flow.

5.10.6 *Equipment Labels*

5.10.6.1 The refrigeration system equipment shall be provided with permanent labels.

5.10.6.2 Compressors, compressor units, condensers, receivers, thermosyphon vessels, recirculator, intercoolers, accumulators, transfer vessels, heat exchangers, and any other similar equipment having an internal volume of more than three cubic feet (0.085 cubic meters) containing the refrigerant shall each be equipped with a permanent label that sets forth the type of refrigerant in such, the type of equipment, and its title that matches with the refrigeration management plan drawings.

5.10.7 *Nameplates*

Each component shall have a nameplate with minimum data that describes or defines the manufacturer's information and its design limits/purpose. *See* section 3 equipment and components.

5.10.8 *Duplicate Nameplates*

5.10.8.1 Where duplicate nameplates are required for pressure vessels and heat exchangers constructed as per the design given in this clause, the nameplate should be as per **5.10.8.5.1**.

5.10.8.2 A duplicate nameplate, if used, shall be installed on the skirt, supports, jacket, or other permanent attachment to a vessel.

5.10.8.3 Duplicate nameplates shall be permanently marked "DUPLICATE."

5.10.8.4 Duplicate nameplates shall be obtained only from the original equipment manufacturer or its assignee.

5.10.8.5 The installer shall certify to the manufacturer that the duplicate nameplate has been applied to the proper vessel, as per the following details:

5.10.8.5.1 *Nameplate details*

Each pressure vessel shall have stamped upon its front plate in a conspicuous position the following particulars:

a) Manufacturer's name;
b) Manufacturer's serial number;
c) Year of manufacture;
d) Maximum WP----- at Temperature---- Deg C;
e) Indian Standard Number (IS No.);
f) Pneumatic test pressure;
g) Date of test; and
h) Inspection authorities official stamp (if applicable).

The figures and letters of stamping shall be at least 8 mm high when stamped directly on vessel or 4 mm high when stamped on a permanently attached nameplate.

The figures and letters shall be legible and stamped fully into the plate. Deep stamping shall be avoided when stamped directly on vessel.

Stamping of vessel may be made directly on the vessel or may be stamped on a permanently attached nameplate so fixed as not to be covered by lagging or insulation.

Permanently attached nameplates shall be used on all vessels of steel plate less than 7 mm thick.

The installer shall provide a copy of the certification to the owner, who shall retain the copy for the certificate.

NOTE — Annex C (Informative) provides further information on duplicate nameplates.

5.10.9 *Equipment Enclosures*

5.10.9.1 Enclosures shall be designed to allow the equipment or components to operate effectively and safely in the location in which they are to be installed.

5.10.9.2 Enclosures shall allow for proper service and maintenance of the equipment/components on site by access panels and/or doors, or by removing the enclosure along with contents from the system for remote service.

5.10.9.3 Enclosures shall provide protection from inadvertent physical and/or environmental damage and meet the cleanliness requirements of the area.

5.11 Pressure Vessel

For details refer **12** of Section 3.

6 MACHINE ROOMS

This clause provides requirements for the design of machinery rooms housing stationary closed-circuit ammonia refrigeration systems or system components.

6.1 Room Layout

6.1.1 The refrigeration machinery room can contain much of the fixed equipment for a refrigerated facility. Equipment installed in machinery rooms shall be located in such a manner as to allow easy access from any part of the room in the event of an emergency.

Provide adequate clearances for maintenance operations and inspections taking equipment manufacturer's instructions into account.

6.1.2 *See* service provisions **5.8** for safe access opening and passageway clearance requirements for serviceable equipment and components.

6.2 Construction

6.2.1 Machine rooms shall be constructed in accordance with the National Building Code in force and the requirements of this clause (*see* **4.3.5** and **12.4.1.5** of Part 8/Section 3 of SP 7).

6.2.2 The machinery room shall be separated from the remainder of the building by tight-fitting construction. *See* **6.10** for entrances and exits.

6.2.3 Where piping or equipment is supported by the roof or ceiling structure, the structure shall be designed to support the expected static and dynamic, including seismic, loads.

6.2.4 Fire prevention shall be part of the machinery room design considerations.

6.2.4.1 The machinery room shall be separated from the remainder of the building by a one-hour (1 h) fire-resistance rated separation.

6.2.5 Foundations and supports for compressor units and other equipment located within the machinery room shall be of non-combustible construction and capable of supporting loads imposed by such units. Manufacturer's recommendations shall be considered. Supports and anchorage for refrigeration equipment and piping shall be designed in accordance with the National Building Code (*see* SP 7).

6.2.6 A compressor or condenser supported from the ground shall rest on a concrete or other approved housekeeping pad base and/or shall be furnished with an approved support base for sitting directly on and anchoring to the foundation.

6.2.7 All machinery shall be mounted in such a manner as to prevent excessive vibration from being transmitted to the building structure or connected equipment that could cause damage. Isolation materials such as rubber are permitted between the foundation and equipment.

6.2.8 There shall be no airflow to or from an occupied space through a machinery room unless the air is ducted and sealed in such a manner as to prevent any refrigerant leakage from entering the airstream. Access doors and panels in duct work and air-handling units shall be gasketed and tight fitting.

6.2.9 The design shall consider and eliminate or reduce sources of abnormal sounds or vibrations of piping, fans, pumps, pressure actuated pumping systems and hydraulic pipe pressure surges/shocks.

6.2.10 Additions to or renovation of existing machinery rooms may be impractical for a variety of reasons and should be done only with careful consideration and in-depth review.

6.3 Accessibility

6.3.1 Refrigerating systems shall be accessible to the fire department at all times as required by the fire code IS 3594 and Part IV of SP 7.

6.3.2 *See* **5.8** service provisions for safe access opening and passageway clearance requirements for serviceable equipment and components.

6.3.3 All manually-operated valves inaccessible from floor level shall be operable from portable platforms, fixed platforms, ladders, or shall be chain- operated.

6.3.4 Isolation valve(s) identified as being part of a system emergency shutdown procedure(s) shall be readily accessible to be directly operable or chain-operated from a permanent work surface. These valves shall be clearly identified. *See* **5.10.4** valve tagging.

6.3.5 Access to the refrigerating machinery room shall be restricted to authorized personnel. Doors shall be clearly marked and permanent signs shall be posted at each entrance to indicate this restriction.

6.3.6 Access for emergency response vehicles shall be in accordance with all state and local codes.

6.3.7 Consult applicable codes, standards and regulations for the access requirements which shall be followed to access refrigerating machinery which are located on different structure levels.

6.3.8 The following site considerations shall be considered during the design review where a refrigerated facility is to be constructed or expanded.

6.3.8.1 *Proximity to surface waters* — Topography of the site shall prevent any possibility of an ammonia spill from reaching surface waters such as drain water, creeks, streams, rivers, lakes, or ponds per all state and central regulations. A site drainage plan shall be prepared for this purpose.

6.3.8.2 *Proximity to off-site and major traffic thoroughfares* — Machinery rooms shall be located on the site with due consideration for proximity to off- site major traffic thoroughfares, nearby neighbors, and prevailing winds. Machinery room location considerations shall include safety, noise hazards and off-site effects. Refer to local and state codes for the requirements.

6.3.8.3 *Proximity to sensitive receptors* — Machinery rooms shall be located to minimize the impact on nearby sensitive receptors, such as schools and nursing homes. Refer to local and state codes for any requirements.

6.3.8.4 *Arrangement of machinery room to overall facility* — The machinery room location relative to the rest of the refrigerated facility is important. Following are lists of possible locations:

6.3.8.4.1 *Preferred locations*

a) Ground level;

b) Separate building (or sharing a building with another utility system);

c) Peninsular part of main building with three exposed walls and exposed roof, remote from heavily occupied areas; and

d) Along exterior of main building having one or two exposed walls and exposed roof, remote from heavily occupied areas.

6.3.8.4.2 *Least desirable*

a) Inner areas of building with no exterior wall exposure;

b) Adjacent to (horizontally or vertically) heavily occupied areas such as office and employee welfare facilities or areas;

c) Basement of building; and

d) Building floors above ground level.

6.4 Combustible Materials

6.4.1 *Flammable*

Flammable material having flash point below 37.8°C (100°F) shall not be stored in machinery room.

NOTE — This provision shall not apply to spare parts, tools and incidental materials necessary for the safe and proper operation and maintenance, of the refrigerating system.

6.5 Open Flames

6.5.1 Fuel-burning appliances and equipment having open flames that use combustion air from the machinery room shall not be installed in a machinery room.

6.5.2 Fuel-burning appliances and equipment with continuously operating surface temperatures in excess of 427°C shall not be installed in a machinery room.

The following exceptions shall be noted:

a) Fuel-burning appliances and equipment that do not operate in excess of 427°C are permitted in the same machinery room where combustion air is ducted from outside the machinery room and sealed in such a manner as to prevent any refrigerant leakage from entering the combustion chamber, or where a refrigerant detector automatically shuts off the combustion process in the event of refrigerant leakage;

b) The use of matches, lighters, sulfur sticks, welding equipment and similar portable devices are permitted, other than during charging or discharging of oil or ammonia, where the machinery room meets the requirements of **6**; and

c) Machinery rooms where internal combustion engines are used as the prime mover for the compressors.

6.6 Piping

6.6.1 Machinery or piping shall not cause condensation or drips onto electrical equipment (*see* **5.9** condensation control). Where this is unavoidable, electrical equipment must be suitably protected.

6.6.2 Piping and fittings shall be properly insulated, where applicable, and adequately placed to mitigate condensation hazards that could cause a hazard to personnel (for example, slips on a wet walking surface) or damage to the structure (for example, mold or mildew) or other equipment (*see* **5.9** condensation control).

6.6.3 All pipes piercing the interior walls, ceiling or floor of the machinery room shall be tightly sealed to the walls, ceiling or floor through which they pass.

6.6.4 All piping shall have appropriate pipe markers attached to indicate its use and the direction of flow. *See* pipe marking **5.10.5**.

6.6.5 There shall be no refrigerant cylinders with temporary or permanent connections to the system unless actual transfer of refrigerant is being conducted by a qualified individual(s). The transfer in progress shall not be left unattended.

6.7 Eyewash/Shower

6.7.1 An eyewash and body shower unit shall be located within each machinery room.

NOTES

1 Additional eyewash and body showers may be needed in a machinery room to ensure that no equipment which contains ammonia inside that machinery room is more than 10 s or 16.8 m from at least one unit

2 Consider installing an eyewash and body shower external to each machinery room and readily accessible via an exit. This eyewash and body shower located external to a machinery room would be used if the unit(s) located inside the machinery room could not be safely accessed in abnormal conditions (for example, if there was an ammonia release inside the machinery room).

6.8 Electrical Safety

6.8.1 Electrical equipment and wiring shall be installed in accordance with SP 30.

6.8.2 A machinery room shall be classified as per the *Indian Electricity Rules* 1956 (Rev 2010-11, as a "Non-hazardous (unclassified) location," when the machinery room is provided with an independent mechanical ventilation system that meets the requirements of **6.14** ventilation.

6.8.3 As per the *Indian Electricity Rules* 1956 (Rev 2010-11, where a mechanical ventilation system is not provided in accordance with **6.14**, the room shall be classified as Class I, Group D, Division 2 location.

6.8.4 Electrical classification shall be clearly documented.

6.8.5 Electrical equipment in the machinery room shall be minimized to equipment directly associated with the refrigeration system.

6.9 Drains

6.9.1 Adequate floor drains shall be provided to properly dispose of all waste water. The accumulation of or the running of wastewater across the floor shall be avoided or be kept to a minimum.

6.9.2 When required, a means shall be provided to prevent contamination (keep out unintended substances-oil, secondary coolants, etc of the drainage system.

6.10 Entrances and Exits

6.10.1 Machinery room doorway exits shall be adequate in number to ensure an unencumbered means for persons to escape in an emergency.

6.10.2 Machinery room doors communicating with the building shall be self-closing, tight-fitting fire rated doors.

6.10.3 The machinery room shall have a door(s) that opens directly to the outside, or to a vestibule that leads directly to the outside. The door(s) shall be self-closing, tight-fitting.

6.10.4 Exterior exits shall not be under any fire escape or any open stairway.

6.10.5 Refrigerating systems shall be provided with approved informative signs, emergency signs, charts and labels.

6.10.6 Each site shall have an appropriate evacuation plan on display. Contact information for persons responsible for emergency procedures shall be clearly shown on the plan. *See* **5.10.2** for emergency shutdown signage requirements.

6.11 Lighting

6.11.1 Machinery rooms shall be equipped with light fixtures to provide a minimum of 320 lumens/m^2 at the working level, 0.91 m above the floor or platform. *See* **7.1** for lighting requirements for equipment and components located outside.

6.11.2 Control of the illumination source shall be provided at the access entrance(s). In lieu of manual controls, the use of occupancy sensors to control lighting or continuous illumination is permitted.

6.12 Refrigeration Machinery Remote Controls

6.12.1 *Refrigeration System Emergency Shut-off*

A clearly identified switch with an approved tamper-resistant cover shall be located outside and adjacent to the designated principal machinery room door(s) which shall provide off-only control of refrigerant compressors, refrigerant pumps, and normally closed automatic refrigerant valves located in the machinery room. Additionally, unclassified electrical equipment shall automatically shut off whenever the refrigerant vapour concentration in the machinery room exceeds the vapour detector's upper detection limit or 25 percent of the Lower Flammability Limit (LFL) or [40 000 ppm], whichever is lower.

6.13 Refrigerant Detection

Each machinery room shall contain refrigerant detection that will activate an alarm and mechanical ventilation as described in this section. A trouble signal indicating fault in the power system for the detection shall be reported to a monitored location so that corrective action can be taken.

6.13.1 *Alarm*

6.13.1.1 A monitored location shall be notified when an ammonia leak is detected.

6.13.1.2 Restrict access to the machinery room to authorized, trained personnel only.

6.13.1.3 The leak detection sensors shall activate visual and audible alarms inside the machinery room and outside each entrance to the machinery room.

6.13.1.4 An audible alarm shall provide a sound pressure level of at least 15 dBA above the ambient sound pressure level of the area in which it is installed.

6.13.1.5 The meaning of each alarm shall be clearly marked by signage near the visual and audible alarms.

6.13.2 *Placement*

6.13.2.1 The leak detection sensors, or the inlet of sampling tubes that draw air to the leak detection sensors, shall be mounted in a position where refrigerant from a leak is most likely to concentrate.

6.13.3 *Detection Levels*

6.13.3.1 Detection of ammonia vapour concentrations below 25 ppm requires no alarm or detection device action. An authorized, trained personnel shall respond and address any indication (for example, odour) of ammonia at this level. The source must be identified and resolved or the appropriate repair implemented in a timely manner.

6.13.3.2 Detection of ammonia vapour concentrations at or above 25 ppm shall activate a visual indicator(s) (for example, strobe or other distinct type) and an audible alarm in the area in which they are installed.

6.13.3.2.1 The visual indicator and audible alarm can be automatically reset when the ammonia vapour concentration falls below 25 ppm.

6.13.3.3 Detection of ammonia vapour concentrations at or above 150 ppm shall activate a visual indicator(s) and an audible alarm in the area in which they are installed and turn on the emergency ventilation system at the emergency ventilation rate. Ventilation fans activated at the 150 ppm detection level shall be latched in and shall require a manual reset within the machinery room.

NOTE — Where operational containment is provided as a means to prevent ammonia vapour from escaping to the environment, the ventilation system can be shut off at a remote location, regardless of concentration level, and according to a pre-developed procedure for implementing operational containment.

6.13.3.4 Detection of ammonia vapour concentrations that exceeds the detector's upper detection limit or 40 000 ppm, whichever is lower, shall activate all visual and audible indicators and automatically shut down normally closed automatic refrigerant valves, ammonia pumps, and compressors in un-classified locations.

6.13.3.4.1 Emergency lighting and power to the emergency ventilation system, as well as other critical systems, shall remain powered (for example, independent circuit) to stay on during an emergency machinery room equipment shutdown.

NOTE — Where operational containment is provided as a means to prevent ammonia vapour from escaping to the environment, the ventilation system can be shut off at a remote location, regardless of concentration level, and according to a pre-developed procedure for implementing an operational containment shutdown provided in accordance with **6.12.1**.

6.13.4 *Signage*

The meaning of each alarm shall be clearly marked by signage near the visual and audible alarms.

6.13.5 *Testing*

6.13.5.1 The facility shall establish a time schedule for testing of the ammonia detectors and the alarm system. The manufacturer's recommendations shall be followed or modified based on documented experience.

6.13.5.2 Where no recommendations are provided, these devices shall be functionally tested on an annual basis.

6.14 Ventilation

6.14.1 *Ventilation for Occupants*

During occupied conditions, outdoor air shall be provided at a rate of not less than 0.002 5 m^3/s per m^2 of machinery room area or 0.009 m^3/s per occupant, whichever is greater.

6.14.2 *General Exhaust and Air Conditioning Equipment*

Machinery room exhaust fans and air conditioning equipment that is not intended for exhausting ammonia vapour shall be de-energized and fan dampers, where provided, shall close upon detection of ammonia.

6.14.3 *Exhaust Ventilation*

Machinery rooms shall be vented to the outdoors by means of a mechanical exhaust ventilation system.

6.14.3.1 Mechanical exhaust ventilation system shall be automatically activated by ammonia leak detection or temperature sensors, and the system shall also be manually operable.

6.14.3.2 Mechanical exhaust ventilation systems shall be designed to produce not less than the temperature control ventilation rate required by **6.14.6** and the emergency exhaust ventilation rate required by **6.14.7**.

6.14.3.3 Exhaust air ducts from the machinery room shall only serve the machinery room.

6.14.4 *Fan Options*

Multiple fans or multispeed fans shall be permitted to provide both temperature control exhaust ventilation in accordance with **6.14.6** and emergency exhaust ventilation in accordance with **6.14.7**. Fans used for both temperature control and emergency ventilation shall be controlled in a manner that provides equal to or greater than the emergency ventilation rate when emergency ventilation is activated.

6.14.5 *Inlet Air*

6.14.5.1 Outdoor make-up air shall be provided to replace air being exhausted and shall be designed to maintain negative pressure in the machinery room, not to exceed 6.4 mm water column.

6.14.5.2 Make-up air supply locations in the machinery room shall be positioned to prevent short-circuiting of the make-up air directly to the exhaust.

6.14.5.3 Make-up air openings shall be covered with a corrosion-resistant screen of not less than 6.35 mm (¼″) mesh or equivalent protection.

6.14.5.4 Intakes for make-up air shall be positioned to draw uncontaminated outdoor air and avoid recirculation of exhausted air.

6.14.5.5 Intakes for make-up air to the machinery room shall only serve the machinery room.

6.14.5.6 Motorized louvers or dampers, where utilized, shall fail to the open position upon loss of power.

6.14.5.7 Where direct openings or openings with ducts are not provided to supply make-up air, make-up air shall be provided by fans or fans with ducts.

6.14.6 *Temperature Control Ventilation*

6.14.6.1 Temperature control mechanical ventilation design capacity shall be the volume required to limit the room dry bulb temperature to 40°C, taking into account the ambient heating effect of machinery in the room. The emergency ventilation system shall be permitted to be used to supplement temperature control ventilation, and vice-versa.

NOTE — A reduced temperature control ventilation rate shall be permitted where a means of cooling is provided or room electrical equipment is designed to accommodate temperatures exceeding a dry bulb temperature of 40°C, in accordance with SP 30.

6.14.6.2 Partial operation of multiple fan system or multi-speed fans shall be permitted to deliver the temperature control ventilation design capacity.

6.14.6.3 Temperature control mechanical ventilation shall be continuous or shall be activated by both of the following;

a) A thermostat measuring space temperature; and
b) A manual control switch, where temperature control ventilation is designed to contribute to emergency ventilation.

6.14.7 *Emergency Ventilation*

6.14.7.1 Emergency ventilation systems shall provide not less than 30 air changes per hour based on the gross room volume. The emergency ventilation system shall be permitted to include temperature control ventilation fans that meet the requirements of **6.14.6.3,** b) and **6.14.8.4**.

NOTE — Where approved, emergency mechanical ventilation shall not be required for a limited-charge refrigeration system that will not yield an ammonia concentration exceeding 40 000 ppm in the machinery room following a release of the entire charge from the largest independent refrigeration circuit, based on the volume calculation determined in accordance with **5.2**. The designer shall provide a copy of the calculations to be retained at the site.

6.14.7.2 Emergency mechanical ventilation shall be activated by both of the following:

a) Ammonia leak detection complying with **6.13**; and
b) A manual control switch provided in accordance with **6.12.2**.

6.14.7.3 Emergency ventilation shall be powered independently of the equipment within the machinery room and shall continue to operate regardless of whether emergency shutdown controls for the machinery room have been activated.

6.14.7.4 A monitored location shall be notified upon loss of power to or failure of the emergency mechanical ventilation system.

6.14.8 *Emergency Exhaust Requirements*

6.14.8.1 Machinery room exhaust shall be to the outdoors not less than 6 m from a property line or openings into buildings.

6.14.8.2 Machinery room exhaust shall discharge vertically upward with a minimum discharge velocity of 762 m/min at the required emergency ventilation flow rate.

6.14.8.3 Machinery room exhaust fans, regardless of function, shall be equipped with non-sparking blades.

6.14.8.4 Emergency exhaust fan motors located in the air stream or inside the machinery room shall be of the totally-enclosed type. Fan motors meeting this requirement are not required to be listed for use in hazardous (classified) location.

6.14.9 *Testing*

6.14.9.1 Schedule for testing the mechanical ventilation system shall be established based on manufacturer's recommendations, unless modified based on documented experience.

6.14.9.2 The mechanical ventilation system shall be tested at least twice in a year.

6.14.9.3 Alarm testing shall comply with **17.3**.

6.14.9.4 Partial operation of a multiple-fan system or multi-speed fans shall be permitted to deliver the temperature control ventilation design capacity.

6.14.9.5 Temperature control mechanical ventilation shall be continuous or shall be activated by both of the following:

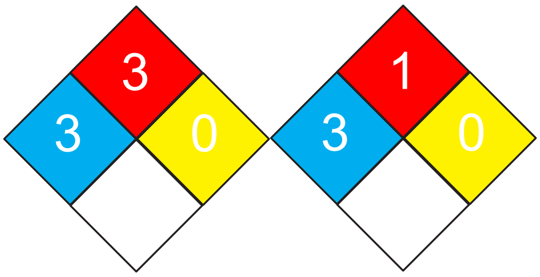
a) A thermostat measuring space temperature; and

b) A manual control switch, where temperature control ventilation is designed to contribute to emergency ventilation.

6.15 Signage

Signage shall be provided according to this clause.

6.15.1 *Graphical Symbols and Safety Colors and safety signs*



Blue colour indicates health — indicates 'can cause serious or permanent injury'.

Red colour indicates flammability — indicates 'must be pre-heated before ignition occurs'.

Yellow colour indicates instability — means 'normally stable even under fire conditions'.

a) **Zero** — Chemicals in this level pose no health hazard and there is no precaution necessary. Chemicals that are entirely safe under normal use can be labelled with a zero in this category;

b) **One** — Level one for the health hazard category is for any chemical that can only cause a mild reaction or injury due to exposure. In most situations, no extra personal protective equipment is needed beyond perhaps gloves;

c) **Two** — Level two is for chemicals that can cause temporary incapacitation or residual injury, but only if there is intense or prolonged exposure to the chemical;

d) **Three** — This level is for chemicals that can cause either a temporary or a moderate residual injury when there is even a short exposure period; and

e) **Four** — Level four chemicals can cause serious injury or death with even brief or limited exposure. Extreme precaution is necessary at this level. Personal protective equipment needs to be worn before working with this chemical or even the container that holds it. This is especially true during an emergency such as a chemical spill.

6.15.2 *Alarm signage*

An alarm signage shall be provided in accordance with **6.13.4** and **17.6**.

6.15.3 *Restricted Access Signage*

Each machinery room entrance door shall be marked with a permanent sign to indicate that only authorized personnel are permitted to enter the room.

7 AREAS OTHER THAN MACHINE ROOMS

This clause applies to areas other than machinery rooms and which are industrial occupancies only. All equipment shall be suitably designed, appropriately oriented, and adequately protected for safe operation in the area in which they are to be installed and according to the provisions given below.

7.1 Common Considerations

When installing refrigerant containing components of a closed-circuit ammonia refrigeration system outside a machinery room, the following considerations must be addressed:

Refer to IS 4544 for emergency eyewash and shower equipment guidelines. Suitable equipment for quick drenching and flushing of the eyes and body shall be provided for immediate emergency use in work areas where operating or maintenance activities could expose personnel to ammonia. *See* **6.7** of machine room requirements.

Condensers, receivers and other outside refrigerating equipment and components shall have lighting per local state government rules, factory act, to permit adequate night time inspection.

NOTES

1 *See* **8** to **16** for specific requirements for equipment and components in specific areas.

2 *See* **7.2** for installation locations for area specific considerations.

3 *See* **17** for ammonia detection and alarm requirements.

7.1.1 *Physical Protection* — The components shall be protected from physical damage by activities in the areas in which they are installed. Methods of protection could include but are not limited to the following:

a) Barriers, guardrails, bollards, fencing, or other structural elements to distance equipment from activities in the area; and
b) Equipment enclosure and/or framework protection designed into its exterior structure to reduce damage if impacted.

7.1.2 *Environment* — The components shall be specifically designed to operate in the environmental conditions of the area in which they are to be installed. Methods of protection could include but not be limited to the following:

a) Materials or finishes and coatings;
b) Protection from temperature extremes;
c) Protection from dust/dirt airborne particles with adequate filtration;
d) Appropriate electrical components for the area;
e) Maintain an acceptable noise level for the area based on the applicable standard or provide appropriate sound attenuation;
f) Components and equipment shall be designed and approved to structurally withstand the expected static and dynamic seismic and wind loads based on the applicable code (*see* **5.7.6**); and
g) Protection from outdoor ultraviolet exposure.

7.1.3 *Personnel*

Restrict access to the components to authorized personnel only. Methods of restrictions could include but are not limited to the following:

a) Company enforced policies, training, and signage defining restricted areas;
b) Fence or barricade the restricted areas; and
c) Equipment designed with security features.

7.1.4 Provide safe access for the inspection and maintenance of the components including all required clearances for servicing. *See* **5.8** service provisions.

7.1.5 All components that require servicing or replacement shall be provided with isolation valves individually or as a group. Pump-out provisions shall be provided for all components and piping branches/circuits that can be isolated. The pump out valve shall be installed to allow for safe and efficient evacuation and/or the removal of the ammonia by a reclaim, recycle, or recovery device. Purging to a water container and/or to the atmosphere is another safe and appropriate method for the controlled removal of the refrigerant. The pump out valves shall be capped for use by authorized and qualified personnel only, unless pump out valves are permanently piped to a central pump out system.

7.1.6 Only semi-hermetic seal-less or hermetically sealed ammonia pumps shall be used in occupied indoor areas other than machinery rooms.

7.1.7 Ammonia gas or liquid pressure-pumping systems shall be located in a machinery room or an equipment enclosure. If neither of these locations are practical for the system operational design and layout, areas in which these systems are located shall meet the requirements of **7.1**.

7.1.8 *Ventilation*

In indoor areas that contain refrigeration equipment, other than forced air evaporators, air cooled and/or evaporative condensers, piping, and valves, provide a mechanical ventilation system(s) per the requirements of this clause. Detection and alarm levels to activate the ventilation systems shall comply with **17**.

7.1.8.1 Ammonia refrigeration systems in indoor areas other than machinery rooms are permitted to use alternative ventilation methods as prescribed in the following sections. Situations where this may apply include the following.

a) Ammonia refrigerating equipment located in processing and production areas;
b) Ammonia refrigerating equipment located in interstitial spaces;
c) In locations where there are sensitive off site receptors, such as densely populated areas, nursing homes, or schools, operational containment is permitted. Refer to **7.1.8.2** for additional provisions required for this alternative ventilation method; and
d) Where all refrigeration equipment is self-contained [the entire refrigeration circuit resides on an assembled package(s)] and the release of the entire charge will not raise the ammonia concentration above 40 000 ppm or 25 percent of the lower flammability limit (LFL), emergency or normal ventilation is not required. Ventilation to maintain room temperature is required if necessary to prevent room dry bulb temperature from rising above 40°C.
    1) Provide and retain calculations which demonstrate that the ammonia concentrations will never exceed 40 000 ppm if ammonia were released from the system. Ammonia detection and alarm(s) shall be provided for notification of an ammonia release to personnel in accordance with **17**.

7.1.8.2 Ammonia refrigeration equipment or systems in an area other than a machinery room, may use the following alternative ventilation method for the design of the mechanical ventilation system(s):

a) Provide localized (spot) ventilation designed to maintain the ammonia concentrations below 40 000 ppm if ammonia were released from the system;

b) The leak rate used for this ventilation calculation shall be 0.320 kg/s;

c) The open room area in which the refrigeration equipment resides shall be used as the volume for determining the concentration level;

d) Ducts, enclosures or hoods may be used for parts of the ventilation system; and

e) Retain the design calculations used to determine the ventilation rate and the ventilation equipment selection.

NOTE — Annex G (Informative) contains sample calculations for the design of a ventilation system using alternative ventilation methods.

7.1.8.3 Operational containment is permitted when the following provisions are met:

a) A refrigerant detection system meeting the requirements of **17** and a ventilation system meeting the requirements of **7.1** must be provided;

b) An operational containment shall be initiated at a detection level determined by the site refrigeration management designee, emergency responders, and/or owner. A pre-determined procedure shall be initiated to ensure that personnel are not located within the machinery room before operational containment is initiated;

c) Provide an “ON/OFF/AUTO” override for emergency ventilation at a secured remote location that can be used for operational containment shutdown of the ventilation system;

d) Automatically de-energize all unclassified electrical equipment at the detection level set forth in **6.13** or upon stopping ventilation using manual controls;

e) Equipment or controls that must remain energized for monitoring or controlling equipment shall be designed for operation in a hazardous location; and

f) Airflow dampers on fans, air inlets and air outlets shall close when an operational containment is actuated.

7.1.8.4 *Ventilation for systems located outdoors*

7.1.8.4.1 When a refrigerating system or a component of a refrigerating system is located outdoors and is enclosed or partially enclosed by a penthouse, lean-to, or other structure, it shall be at least 6 m from building entrances and exits and natural or mechanical ventilation shall be provided. The requirements for such natural ventilation are as follows:

The free-aperture cross section for the ventilation of a machinery room shall be at least:

$$F = 0.138G^{0.5} \text{ (SI)}$$

where

F = the free opening area, m²; and

G = the mass of refrigerant in the largest system, any part of which is located in the machinery room, kg.

7.1.8.5 *Ventilation systems for equipment pits located indoors*

7.1.8.5.1 When refrigeration equipment containing ammonia is located within an indoor pit that is 1.52 m or more below the floor or grade level, emergency ventilation shall be provided in accordance with **6.14.7**.

7.1.8.5.2 Make-up air shall be provided near the floor of the indoor pit. Air shall be directed toward the equipment or components and away from the pit exit.

7.1.8.5.3 The ventilation provisions of the room in which it is located shall be met. The volume of the pit shall be included in the air quantity calculations.

7.2 Locations

This clause provides a partial list of areas outside the machinery room where refrigeration equipment and components might be installed. Each location lists specific installation considerations for the area. Every facility is unique and must be individually evaluated for safe component locations. Equipment located in the following areas shall meet the requirements of **5.8** service provisions. Additionally, design criteria specific to the individual components are contained within the specific equipment clause of this standard.

7.2.1 *Processing and Production Areas*

7.2.1.1 Installed equipment shall meet the cleanliness requirements (for example, food safety) of the area.

7.2.2 *Storage Areas-Refrigerated and Non- Refrigerated*

7.2.2.1 Protect component(s) from material handling equipment.

7.2.3 *Loading Docks-Refrigerated and Non- Refrigerated*

7.2.3.1 Protect component(s) from material handling equipment.

7.2.4 *Outdoors On-Grade, Stands on the Roof*

7.2.4.1 Equipment and components shall be designed to operate in outdoor conditions and meet the requirements of **7.1** common considerations.

7.2.5 *Penthouses*

7.2.5.1 Penthouses open to the interior space are considered part of the refrigerated storage area and shall be treated as such.

7.2.5.2 Penthouses isolated from the interior space shall be treated as an equipment enclosure. *See* **3.52** and **5.10.9**.

7.2.6 *Unoccupied Spaces, Attics, Interstitial Spaces and Basements*

7.2.6.1 Equipment located in any of these areas shall follow the requirements as defined in the specific equipment requirement.

7.2.6.2 Other refrigeration components shall require a minimum level 1 alarm and detection level (*see* **17**).

7.2.7 *Electrical Room*

7.2.7.1 Electrical rooms without spark producing equipment (that is, rooms containing only transformers).

7.2.7.1.1 Install the evaporator unit so that it is protected from impact or damage.

The evaporator can be a direct ammonia or a secondary coolant unit.

7.2.7.1.2 Install an ammonia detection sensor so that when ammonia is detected it de-energizes all applicable feed solenoids (for example, liquid, hot gas) at a value not greater than the corresponding TLV-TWA.

7.2.7.1.3 The detector shall activate a visual and audible alarm inside the room and outside the room at the entrance of the electrical room.

7.2.7.2 Electrical rooms with spark producing equipment (that is, across the line starters) shall not contain direct system evaporators. Indirect closed systems in which a secondary coolant passes through a closed-circuit in the evaporator unit, are permitted.

SECTION 3 : EQUIPMENT AND COMPONENTS

8 COMPRESSORS

This clause applies to compressors which are used in closed-circuit ammonia refrigerating systems.

Compressors are a vital component in a vapour compression industrial refrigeration system. Compressors are the principle prime movers responsible for providing the motive force for circulating refrigerant throughout a system and for creating a sufficiently high refrigerant pressure differential that allows the transfer of heat from spaces or products to the outside environment. Compressors are the single largest consumer of primary energy (usually electricity) in a refrigeration system. The compressor technologies are reciprocating and screw compressors. Depending on the plant size, pressure ratio and other parameters number of compressors, type or a combination can be decided.

8.1 Design

8.1.1 Minimum design pressure for high stage compressors with water-cooled, or evaporative condensing shall be 2 070 kPa gauge and for air cooled 2 760 kPa gauge.

NOTE — For reciprocating compressors, minimum low side design pressure shall be 2 070 kPa gauge.

8.1.2 Minimum design pressure for booster compressors shall be 2 070 kPa gauge.

8.2 Positive Displacement Compressor Protection

8.2.1 When equipped with a stop valve in the discharge connection, every positive displacement compressor shall be equipped with a pressure relief device selected to prevent the discharge pressure from increasing to more than 10 percent above the maximum allowable working pressures of the compressor, and any other components located in the path between the compressor and the stop valve. Such pressure relief device shall be sized to accommodate the output of the compressor or in accordance with **15.2.7**, whichever is larger.

8.2.2 All exposed rotating components (for example, shafts, belts, pulleys, flywheels, couplings) shall be protected with screens or guards in accordance with approved safety standards.

8.2.3 If rotation is to be in only one direction, a rotation arrow shall be cast in or permanently attached to the compressor frame.

8.2.4 For ultimate strength requirements, *see* **5.9.2**.

8.3 Procedures/Testing

8.3.1 Compressors shall be hydrostatically/ pneumatically tested by the manufacturer at a pressure not less than 1.5 or 1.25 times the design pressure respectively for which they are rated.

8.3.2 Compressors shall be tested and proven tight by the manufacturer at a pressure not less than the design pressure for which they are rated.

8.4 Equipment Identification

8.4.1 The following data shall be provided on nameplates or labels affixed to compressors:

a) Manufacturer's name;
b) Manufacturer's serial number;
c) Model number;
d) Year of manufacture;
e) Hydrostatic test pressure;
f) Maximum allowable working pressure;
g) Refrigerant 'Ammonia';
h) Rotation speed in rpm, maximum and minimum for proper lubrication;
j) Direction of rotation (where applicable) (*see* **8.2.4**); and
k) Flow direction oil or refrigerant.

8.4.2 A compressor without a nameplate (*see* **8.4.1**) shall not be used (or operated) in a project design (for example, used compressor) unless the applicable compressor operating limitations have been verified through the identification of the manufacturer and model number of the compressor from casting numbers.

8.5 Compressor Installation Considerations

Regardless of location, the following considerations in addition to the common considerations and site specific considerations must be addressed when installing a compressor.

8.5.1 All compressors shall have valved pump out connections for removal of ammonia.

8.5.2 Consideration shall be given to the additional heat load imposed on the refrigeration system when locating the compressor in a refrigerated space.

8.5.3 Consideration shall be made to account for the impact on the compressor if operating in low ambient temperatures, to avoid condensation of refrigerant in the compressor package or piping during operation or standby also proper lubricating oil needs to be selected and crankcase heating.

8.5.4 Consideration shall be given to account for the impact on the compressor if operating in high ambient temperatures, to avoid overheating of compressor drive, oil and components.

8.5.5 The compressor manufacturer's instructions shall be followed for installing compressor foundations, proper grouting, and proper isolation from the floor or structure of the building.

8.5.6 When mounting compressors on building structures, consideration shall be taken to prevent excessive vibration.

8.5.7 When a variable frequency drive (VFD) is installed on a compressor, the building structure, foundation/ pad, anchorage, and mounting shall be installed to prevent excessive vibration and assure the compressor is stable at all frequencies during its operation.

8.5.8 The refrigeration compressor design limitations specified by the compressor manufacturer shall be checked for the following:

a) Compressor speed;
b) Compression ratio;
c) Compressor design discharge pressure;
d) Compressor design maximum crankcase/ housing pressure; and
e) Compressor designed for use with ammonia refrigerant.

8.5.9 The compressor drive motor shall comply with relevant Indian Standards.

8.5.10 Each compressor shall be fitted with a discharge check valve. Refer to **13.2.5.6** for stop valves.

8.5.11 Each compressor shall be equipped with the following operable safety controls as a minimum:

a) Low pressure cutout switch;
b) High pressure cutout switch;
c) Low oil pressure cutout switch (if the compressor uses forced feed lubrication); and
d) Oil pressure switch in case of oil pump.

8.5.12 Before using in a new design, each compressor considered shall be inspected for any signs of alteration, modification, or physical repair that might affect the integrity of the compressor casing. Any compressor integrity issue shall be corrected and verified before operation.

8.5.13 If the compressor casing has been altered, modified or repaired, the casing shall already have been recertified for pressure compliance by the manufacturer or insurance underwriter and recertification papers shall be maintained on site with the refrigeration management program.

8.5.14 The compressor shall be fitted with indicating device(s) such that an observer can determine the compressor's suction and discharge pressures, oil pressure (if the compressor uses forced feed lubrication) and discharge temperature.

8.6 Alarms and Detection

Compressors located indoors in areas outside the machinery room shall use level 4 detection.

9 REFRIGERANT PUMPS

This clause applies to mechanical refrigerant pumps applied for use in closed-circuit ammonia refrigerating systems. This requirement does not apply to liquid refrigerant transfer employing pressure differential to move liquid refrigerant.

The refrigerant pumps are recommended for industrial refrigeration system where the system is designed with forced circulation of the refrigerant on the low-pressure side.

The layout and dimensioning of the pumps depends on the refrigeration output, the circulation factor, the evaporation temperature, the design of the evaporator and the geometric layout of the system.

9.1 Design

9.1.1 Pump casing minimum design pressure requirements are as follows:

a) High side service utilizing water-cooled, air-cooled, or evaporative condensing: 2 070 kPa gauge; and
b) Low side service: 2 070 kPa gauge.

NOTE — Application design pressures which exceed these minimum shall prevail.

9.1.2 A hydrostatic or differential pressure relief device (or non-closeable vent pipe) shall be used for pressure protection of a liquid pump and its associated piping. The inlet connection for the relief device or vent pipe shall be located on the pump casing or piping between the stop valves at the pump inlet and outlet, except that when a check valve is located between the pump and its outlet stop valve, the relief device or vent pipe inlet shall be connected to the pipe between the discharge check valve and stop valve. The discharge of this relief or vent pipe shall connect either to the pump suction line upstream of the pump suction stop valve or to the vessel to which the pump suction is connected. This pressure relief device or vent pipe shall be external to the pump housing.

9.1.3 For ultimate strength requirements, *see* **5.9.2**.

9.1.4 Refrigerant pumps shall be suitable for the service in which they are being applied. For refrigerant pumps used in areas other than machinery rooms, *see* **7.1.6**.

9.1.5 Refrigerant pumps shall be installed with isolation valves.

9.1.6 Refrigerant pumps shall be installed on an approved housekeeping pad base or be supplied with an approved structural support base.

9.2 Procedures/Testing

Refrigerant pumps shall be hydrostatically/pneumatically tested by the manufacturer at a pressure not less than 1.5 or 1.25 times the design pressure respectively for which they are rated.

9.3 Equipment Identification

Manufacturers producing refrigerant pumps shall permanently affix to the pump a nameplate providing the following minimum data:

a) Manufacturer's name;
b) Manufacturer's serial number;
c) Manufacturer's model number;
d) Head differential pressure (ft, m, or psi or kg/cm^2);
e) Revolution per minute (RPM) (speed);
f) Capacity (gpm or liters/s);
g) Insulation classification; and
h) Electric motor rating: volts, full load amps (FLA), frequency (Hz), phase, output (HP and/or KW).

NOTE — The pump data sheet submitted shall include the following information:

1) Refrigerant type (for example, ammonia);
2) Operating condition data;
3) Performance data;
4) Construction data – including maximum (allowable) pressure at operating temperature, hydrostatic test pressure, bearing type, and impeller data;
5) Materials – metals and gaskets;
6) Motor (Driver) information-BkW/kW;
7) Piping plan;
8) Operating procedure;
9) Inspections and tests verification – (performance and hydrostatic);
10) Minimum circuit amps (MCA) and maximum over-current protection (MOCP) – (if applicable);
11) Weight; and
12) Direction of rotation shall be confirmed and documented (mark or label a directional arrow on the unit).

9.4 Refrigerant Pumps Installation Considerations

Regardless of location, the following considerations in addition to the common considerations and the site specific considerations must be addressed when installing refrigerant pumps:

9.4.1 Refrigerant pumps are permitted to be semi-hermetic seal-less, hermetically sealed, or open drive. For pumps used in occupied areas other than machinery rooms or outdoors, *see* **7.1.6**.

9.4.2 Pump safeties shall be tied into an alarm and shut down system.

9.4.3 Consideration for design load shall be given to the additional heat imposed on the refrigeration system from the motor heat when locating the pumps in a refrigerated space.

9.4.4 Higher than design ambient temperatures shall be addressed when installing pumps in an unconditioned space.

9.4.5 All pumps shall have valves pump out connections for removal of ammonia.

9.5 Alarms and Detection

9.5.1 For refrigerant pumps located in machinery rooms, *see* **6.13** refrigerant detection.

9.5.2 Semi-hermetic seal-less and hermetically sealed refrigerant pumps located indoors in areas outside the machinery room shall be used. The refrigerant pump motor shall be designed so that the exterior pump wall will contain the rated pressure of the system.

10 CONDENSERS

10.1 Air-Cooled Condensers and Air-Cooled De-superheaters

This clause applies to tube-and-fin and microchannel type air cooled condensers and air cooled de-superheaters which are applied to closed-circuit ammonia refrigerating systems.

10.1.1 *Design*

10.1.1.1 Minimum design pressure shall be 2 760 kPa gauge.

10.1.1.2 For ultimate strength requirements, *see* **5.9.2**.

10.1.1.3 Where the refrigerant inlet and outlet lines of air-cooled condensers and de-superheaters can be automatically isolated, they shall be protected from hydrostatic pressure as per **15.5**.

10.1.1.4 All exposed rotating components (for example, shafts, fans, belts, pulleys, flywheels, couplings) shall be protected with screens or guards in accordance with approved safety standards.

10.1.1.5 Fan speeds shall not exceed the safe design speed recommended by the manufacturer for the temperature and the nature of the application.

10.1.1.6 A condenser or portion of a condensing unit supported from the ground shall rest on a concrete or other approved housekeeping pad base.

10.1.2 *Equipment Identification*

The following data shall be provided on nameplates or labels affixed to the equipment:

a) Manufacturer’s name;
b) Manufacturer’s serial number;
c) Model number;
d) Year of manufacture;
e) Design pressure;
f) Direction of fan rotation;
g) Electric motor power rooting in kW; and
h) Electric supply: volts, full load amps, frequency (Hz), phase.

NOTE — Nameplate data is not required on air cooled de-superheaters that are integral with condensers.

10.1.3 *Air Cooled Condenser Installation Considerations*

Regardless of location, the following considerations in addition to the common considerations and the site specific considerations must be addressed when installing air cooled condensers:

a) Manufacturer’s recommended clearances for unobstructed airflow at the inlet and outlet of the air-cooled condenser shall be provided;
b) Air cooled condensers shall be located and positioned to prevent short circuiting the discharge air and introduction of the warm discharge air into buildings; and
c) Consideration shall be given to the location of the air-cooled condenser relative to the receiver that it will allow sufficient refrigerant head for the refrigerant to properly drain into receiving.

10.1.4 *Alarms and Detection*

Air cooled condensers located indoors in areas outside the machinery room shall use, at a minimum, level 2 detection *see* **17.6**.

10.2 Evaporative Condensers and Natural Draft Water Cooled Condenser

This clause applies to evaporative condensers which are applied to closed-circuit ammonia refrigerating systems.

10.2.1 *Design*

10.2.1.1 Minimum design pressure shall be 2 070 kPa gauge.

10.2.1.2 For ultimate strength requirements, *see* **5.9.2**.

10.2.1.3 Pressure vessels incorporated into evaporative condensers shall comply with **12** pressure vessels.

10.2.1.4 Where the refrigerant coil inlet and outlet lines of evaporative condensers can be automatically isolated, the condenser shall be protected from refrigerant hydrostatic pressure per **15.5**.

10.2.1.5 The requirements specified are as under:

a) Heavy duty steel to be used for fabrication;
b) The guards to be powder coated to prevent rusting;
c) The belt guard shall be removable type for easy removal of belts and adjustments;
d) The belt guard to ensure all movable parts are guarded;
e) The guard must be fitted so that it does not prompt operator to bypass and circumvented or overcome their use;
f) The fitting of guard must be such that it is light weight, easily removable and reinstalled quickly and easily; and
g) Maximum aperture in the net should not be bigger than 6 mm and should not be possible for operator to insert hand or finger.

10.2.1.6 Fan speeds shall not exceed the safe design speed recommended by the manufacturer for the temperature and the nature of the application.

10.2.1.7 All evaporative condensers shall be adequately anchored and supported.

10.2.1.8 Access to evaporative condensers for normal service requirements shall not pose a hazard to service and maintenance personnel.

10.2.1.9 The efficacy of the water distribution system and mist eliminators on each evaporative condenser shall be checked to meet the flow capacity and surface distribution design requirements.

10.2.2 *Equipment Identification*

The following data shall be provided on nameplates or labels affixed to the equipment or components of the equipment:

a) Manufacturer's name;
b) Manufacturer's serial number;
c) Model number;
d) Year of manufacture;
e) Design pressure;
f) Direction of fan rotation (and water circulating pump, if supplied);
g) Electric motor rating for fan(s) (and water circulating pump, if supplied); and
h) Electric supply: volts, full load ampere, frequency (Hz), and phase.

10.2.3 *Evaporative Condensers Installation Considerations*

Regardless of location, the following considerations in addition to the common and the specific considerations must be addressed when installing evaporative condensers:

a) Provide for unobstructed airflow into and out of the evaporative condenser with manufacturer's recommended clearances from structures or other condensers;
b) Evaporative condensers shall be located and positioned to prevent short circuiting the discharge air and introduction of the warm discharge air into buildings;
c) Provide freeze protection, if applicable, for the sump and water piping;
d) Provide proper drainage of overflow and waste water; and
e) Consideration shall be given to the location of the evaporative condenser relative to the receiver such that it will allow sufficient refrigerant head for the refrigerant to/properly drain in receiving.

10.2.4 *Alarms and Detection*

Evaporative condensers located indoors (with the tops open to the outdoors) outside the machinery room shall use, at a minimum, level 2 detection (*see* **17.6**).

10.3 Shell-and-Tube Condensers

This applies to shell-and-tube condensers which are applied in closed-circuit ammonia refrigerating systems.

Equipment covered by this clause are horizontal condensers with closed water passes and vertical shell-and-tube with open water passes.

10.3.1 *Design*

10.3.1.1 The refrigerant side maximum allowable working pressure shall be at least 2 070 kPa gauge.

10.3.1.2 For water side ultimate strength requirements, *see* **5.9.2**.

10.3.1.3 Pressure vessels incorporated into shell-and-tube condensers shall comply with **12** pressure vessels.

10.3.1.4 Where the refrigerant inlet and outlet lines of shell-and-tube condensers can be isolated, the refrigerant side shall be pressure-relief protected per **15.2**.

NOTE — Where the condenser is not a pressure vessel it shall be protected from hydrostatic pressure per **15.5** in place of **15.2**.

10.3.1.5 Where the secondary coolant inlet and outlet lines of shell-and-tube condensers can be isolated, they shall be protected from hydrostatic over pressure.

10.3.1.6 A condenser or portion of a condensing unit supported from the ground shall rest on a concrete or other approved housekeeping pad base.

10.3.2 *Shell-and-Tube Condenser Installation Considerations*

Regardless of location, the following considerations in addition to the common considerations and the site specific considerations must be addressed when installing shell-and-tube condensers:

a) Consideration shall be given for proper clearance for the maintenance and/or replacement of the condenser tubes;

b) Water supply and discharge connections shall be made in accordance with the requirements of pollution control board;

c) Consideration shall be given to the location of the shell-and-tube condenser relative to the receiver that it will allow sufficient refrigerant head for the refrigerant to properly drain in receiver; and

d) The ambient temperatures in the location where the shell-and-tube condenser is installed shall be considered in the design of the also secondary coolant side of the condenser.

10.3.3 *Alarms and Detection*

Shell-and-tube condensers located indoors in areas outside the machinery room shall use, at a minimum, level 2 detection. *See* **17.6**.

10.4 Plate Heat Exchanger Condensers

This clause applies to plate heat exchanger condensers which are applied in closed-circuit ammonia refrigerating systems.

Equipment covered includes plate heat exchanger condensers of the plate-and-shell type and of the plate-and-frame type.

10.4.1 *Design*

10.4.1.1 The refrigerant side maximum allowable working pressure shall be at least 2 070 kPa gauge.

10.4.1.2 For ultimate strength requirements, *see* **5.9.2**.

10.4.1.3 Pressure vessels incorporated into plate heat exchanger condensers (for example, the shell of a plate-and- shell condenser with refrigerant in a shell qualifying as a pressure vessel) shall comply with **12** pressure vessels.

10.4.1.4 Where the refrigerant inlet and outlet lines of refrigerant-containing plate packs can be isolated, the refrigerant side of the plate pack shall be pressure-relief protected as per **15.2**.

NOTE — Where the condenser is not a pressure vessel, it shall be protected from hydrostatic pressure as per **15.5** in place of **15.2**.

10.4.1.5 Where the process fluid (that is, non-refrigerant) inlet and outlet lines of plate packs can be isolated, they shall be protected from hydrostatic pressure per **15.5**.

10.4.2 *Installation Consideration*

Plate heat exchanger condenser installation considerations regardless of location, the following considerations in addition to the common considerations and the site specific considerations must be addressed when installing plate heat exchanger condensers:

a) Water supply and discharge connections shall be made in accordance with the requirements of Pollution Control Board;

b) Consideration shall be given for proper clearance for the maintenance and/or replacement of the condenser plates;

c) Consideration shall be given to the location of the plate heat exchanger condenser relative to the receiver that it will allow sufficient refrigerant head for the refrigerant to properly drain into receiving; and

d) The ambient temperatures in the area the plate heat exchanger condenser is installed shall be considered in the design of the secondary coolant side of the condenser.

10.4.3 *Alarms and Detection*

Plate heat exchanger condensers located indoors in areas outside the machinery room shall use, at a minimum, level 2 detection (*see* **17.6**).

10.5 Double-Pipe Condensers

This clause applies to double-pipe condensers which are applied in closed-circuit ammonia refrigerating systems.

Equipment covered by this section are double-pipe condensers with closed water passes.

10.5.1 *Design*

10.5.1.1 The refrigerant side maximum allowable working pressure shall be at least 2 070 kPa gauge.

10.5.1.2 For secondary coolant side ultimate strength requirements, *see* **5.9.2**.

10.5.1.3 Pressure vessels incorporated into double-pipe condensers shall comply with clause **12** pressure vessels.

10.5.1.4 Where the refrigerant inlet and outlet lines of double-pipe condensers can be isolated, the refrigerant side shall be pressure-relief protected as per **15.2**.

NOTE — Where the condenser is not a pressure vessel it shall be protected from hydrostatic pressure per **15.5** in place of **15.2**.

10.5.1.5 Where the water inlet and outlet lines of double-pipe condensers can be isolated they shall be protected from hydrostatic pressure per **15.5**.

10.5.2 *Double-Pipe Condenser Installation Considerations*

Regardless of location, the following considerations in addition to the common considerations and the site specific considerations must be addressed when installing double-pipe condensers:

a) Water supply and discharge connections shall be made in accordance with the requirements of Pollution Control Board;
b) Consideration shall be given for proper clearance for the maintenance and/or replacement of the condenser pipes;
c) Consideration shall be given to the location of the double-pipe condenser relative to the receiver that it will allow sufficient refrigerant head for the refrigerant to properly drain; and
d) The ambient temperatures in the area the double-pipe condenser is installed shall be considered in the design of the secondary coolant side of the condenser.

10.5.3 *Alarms and Detection*

Double-pipe condensers located indoors in areas outside the machinery room shall use, at a minimum, level 2 detection (*see* **17.6**).

10.6 Procedures/Testing

Air cooled condensers, evaporative condenser, shell and tube condenser, plate heat exchanger, double pipe condenser shall be strength tested at a pressure 1.5 times the design pressure, and leak tested and proven tight at a design pressure pneumatically (dry air/dry nitrogen) by the manufacturer.

10.7 Equipment Identification

10.7.1 Manufacturers producing shell-and-tube condensers shall provide the following minimum data on a nameplate affixed to the equipment:

a) Manufacturer’s name (preceded by the words “certified by” on nameplates);
b) Shell/Plate side maximum allowable working pressure _____at ______temperature;
c) Tube/Plate side maximum allowable working pressure _____at ______temperature;
d) Shell/Plate side minimum design metal temperature_____at______pressure;
e) Tube/Plate side minimum design metal temperature_____at______pressure;
f) Manufacturer’s serial number;
g) Model number (where applicable);
h) Year of manufacture; and
j) Manufacturers producing shell-and-tube condensers with integral pressure vessels (for example, condensers with refrigerant in a shell qualifying as a pressure vessel) shall provide design data.

10.8 Nameplate Mounting

10.8.1 The original nameplate shall be affixed to the equipment as specified in **5.10.8.5.1**.

10.8.2 Where duplicate nameplates are supplied, they shall comply with **5.10.8.5.1**.

11 EVAPORATORS

11.1 Forced-Air Evaporator Coils

This clause applies to evaporator coils and micro-channel heat exchangers which are applied to closed-circuit ammonia mechanical refrigerating systems.

11.1.1 *Design*

11.1.1.1 Minimum design pressure shall be 1 720 kPa gauge.

11.1.1.2 For ultimate strength requirements, *see* **5.9.2**.

11.1.1.3 Where refrigerant coil inlet and outlet lines can be automatically isolated, they shall be protected from hydrostatic pressure per **15.5**.

11.1.1.4 All exposed rotating components (for example, fans, shafts, belts, pulleys, flywheels, couplings) shall be protected with screens or guards in accordance with governing safety standards.

11.1.1.5 Fan speeds shall not exceed the safe design speed recommended by the manufacturer for the temperature and the nature of the application.

11.1.1.6 All evaporators shall be properly anchored and supported.

11.1.2 *Forced-Air Evaporator Coil Installation Considerations*

Regardless of location, the following considerations in addition to the common considerations and the site specific considerations must be addressed when installing forced-air evaporator coils in areas other than the machinery room:

a) Manufacturer's recommended clearances for unobstructed airflow at the inlet and outlet of the forced-air evaporator shall be provided;
b) Evaporators shall be arranged for proper air distribution to maintain required space temperatures;
c) Optimal air flow for working conditions for the area personnel shall be considered;
d) Evaporators shall be arranged to avoid short circuiting of air between evaporators;
e) Evaporators will be arranged to minimize interference with area operation;
f) Evaporators will be arranged such that they are not exposed to possible physical damage through traffic hazards from material handling equipment and vehicles (*see* **7.1.1**); and
g) A means for preventing freezing inside condensate drain lines shall be provided where lines are exposed to freezing temperatures (for example, sufficient line slope, heat trace, insulation, clean-out provisions).

11.1.3 *Alarms and Detection*

Forced-air evaporators located in refrigerated areas outside the machinery room (for example, freezers, cold rooms, docks) shall not require detection, although it is recommended. *See* **17.6** for detection level considerations.

11.2 Shell-and-Tube Evaporators (with Refrigerant in Shell)

This applies to shell-and-tube evaporators which are applied to closed-circuit ammonia refrigerating systems at any temperature level when evaporating refrigerant is used to cool another fluid.

11.2.1 *Design*

11.2.1.1 The shell maximum allowable working pressure shall be at least 1 720 kPa gauge or the pressure corresponding to the design saturated temperature of the anticipated process, whichever is greater.

11.2.1.2 Pressure vessels incorporated into shell-and-tube evaporators shall comply with **12** pressure vessels.

11.2.1.3 Where the tube-side inlet and outlet lines of shell and tube evaporators with refrigerant in shell can be isolated, the tube-side shall be protected from hydrostatic pressure as per **15.5**.

11.2.1.4 Heat loads from cleaning operations or process loads shall be considered when designing the relief capacity and control of process heat exchangers.

11.2.2 *Shell-and-Tube Evaporators (with Refrigerant in Shell) Installation Considerations.*

See **11.3.2**.

11.2.3 *Alarms and Detection*

See **11.3.3**.

11.3 Shell-and-Tube Evaporators (with Refrigerant in Tubes)

This clause applies to shell-and-tube evaporators which are applied to closed-circuit ammonia refrigerating systems at any temperature level when evaporating refrigerant is used to cool another fluid.

11.3.1 *Design*

11.3.1.1 The shell side maximum allowable working pressure shall be at least 1 720 kPa gauge or the pressure corresponding to the design saturated temperature of the anticipated process, whichever is greater.

11.3.1.2 Where the tube-side inlet and outlet lines of shell-and-tube evaporators (tubes) can be isolated, the tube-side shall be pressure-relief protected as per **15.5**.

NOTE — Where the tube-side of the evaporator is built and stamped in accordance with **11.3.1.3**.

Pressure vessels incorporated into shell-and-tube evaporators with refrigerant in tubes shall comply with **12**.

11.3.1.3 Heat loads from cleaning operations and process loads shall be considered when designing the relief capacity and control of process heat exchangers.

11.3.2 *Shell-and-Tube Evaporators (with Refrigerant in Shell or in Tubes) Installation Considerations*

Regardless of location, the following considerations in addition to the common considerations and the site specific considerations must be addressed when installing shell-and-tube evaporators:

a) Consideration shall be given for proper clearance for the maintenance and/or replacement of the evaporator tubes; and
b) The ambient temperatures in the area the shell-and-tube evaporator is installed shall be considered in the design of the secondary coolant side of the evaporator.

11.3.3 *Alarms and detection*

Shell-and-tube evaporators (with refrigerant in shell or in tubes) located indoors in areas outside the machinery room shall use, at a minimum, level 2 detection. *See* **17.6**.

11.4 Plate Heat Exchanger Evaporators

This applies to plate heat exchanger evaporators which are applied to closed-circuit ammonia refrigerating systems.

Equipment covered by this section include plate heat exchanger evaporators of the plate-and-shell type, and of the plate-and-frame type in which the heat transfer plate stack is axially contained between two pressure plates and where the plate joints may be fully elastomeric, paired plate sets welded with adjacent sets elastomeric, fully welded, or fully nickel brazed.

11.4.1 *Design*

11.4.1.1 Minimum refrigerant side design pressure shall be 1 720 kPa gauge or the pressure corresponding to the design saturated temperature of the anticipated process, whichever is greater.

11.4.1.2 For ultimate strength requirements, *see* **5.9.2**.

11.4.1.3 Pressure vessels incorporated into plate heat exchanger evaporators (for example, plate-and-shell designed with refrigerant in a shell qualifying as a pressure vessel) shall comply with **12**.

11.4.1.4 Where the refrigerant inlet and outlet lines of refrigerant-containing plate packs can be isolated, the refrigerant side of the plate pack shall be pressure-relief protected as per **15.5**.

NOTE — Where the evaporator is not a pressure vessel, it shall be protected from hydrostatic pressure as per **15.5** in place of **15.2**.

11.4.1.5 Where the process fluid (that is, non-refrigerant) inlet and outlet lines of plate packs can be isolated, they shall be protected from hydrostatic pressure as per **15.5** on the process side.

11.4.1.6 Heat loads from cleaning operations or process loads shall be considered when designing the relief capacity and control of process heat exchangers.

11.4.2 *Plate Heat Exchanger Evaporators Installation Considerations*

Regardless of location the following considerations in addition to the common considerations and the site specific considerations must be addressed when installing plate heat exchanger evaporators:

a) Consideration shall be given for proper clearance for the maintenance and/or replacement of the evaporator plates; and
b) The ambient temperatures in the area the plate heat exchanger evaporator is installed shall be considered in the design of the secondary coolant side of the evaporator.

11.4.3 *Alarms and Detection*

Plate heat exchanger evaporators located indoors in areas outside the machinery room shall use, at a minimum, level 2 detection. *See* **17.6**.

11.5 Scraped (Swept) Surface Heat Exchangers

This applies to scraped (swept) surface heat exchangers which are applied to closed-circuit ammonia refrigerating systems.

11.5.1 *Design*

11.5.1.1 The shell maximum allowable working pressure shall be at least 1 720 kPa gauge or the pressure corresponding to the design saturated temperature of the anticipated process, whichever is greater.

11.5.1.2 Pressure vessels incorporated into scraped surface heat exchangers shall comply with clause **12** pressure vessels.

11.5.1.3 Heat loads from cleaning operations or process loads shall be considered when designing the relief capacity and control of scraped surface heat exchangers.

11.5.2 *Scraped (Swept) Surface Heat Exchanger Installation Considerations*

Regardless of location, the following considerations in addition to the common considerations and the site specific considerations must be addressed when installing scraped (swept) surface heat exchangers:

a) Consideration shall be given for proper clearance for the maintenance and/or replacement of components; and
b) The ambient temperatures in the area the scraped (swept) surface heat exchanger is installed shall be considered in the design.

11.5.3 *Alarms and Detection*

Scraped (swept) service heat exchangers located indoors in areas outside the machinery room shall use, at a minimum, level 2 detection. *See* **17.6**.

11.6 Procedures/Testing

Forced air evaporator coils, shell and tube evaporators, shell and tube evaporators (with refrigerant in tubes), plate heat exchanger evaporators, and scraped (swept) surface heat exchangers shall be strength tested at a pressure 1.5 times the design pressure, and leak tested and proven tight at a design pressure pneumatically (dry air/dry nitrogen) by the manufacturer.

11.7 Equipment Identification

Following data shall be printed on nameplate or label affixed to the equipment for shell and tube evaporators, shell and tube evaporators (with refrigerant in tubes), plate heat exchanger evaporators and scraped (swept) surface heat exchangers:

a) Certification and stamping as per **5.10.8.5.1**;
b) Manufacturer's name (preceded by the words "certified by,";
c) Shell/Plate side maximum allowable working pressure at temperature;
d) Tube side maximum allowable working pressure at temperature;
e) Shell/Plate side minimum design metal temperature at pressure;
f) Tube/Plateside minimum design metal temperature at pressure;
g) Manufacturer's serial number;
h) Model number (where applicable);
j) Year of manufacture;
k) Test pressure (note test type; hydraulic or pneumatic);
m) Pressure vessel design as per **5** and **12** of this standard; and
n) A stamp shall be affixed to the equipment that includes the minimum design metal temperature (MDMT) that it is operated at in accordance with pressure vessel requirement, where applicable.

11.8 Nameplate Mounting

11.8.1 The original nameplate shall be affixed to the equipment as specified in **5.10.8.5.1**.

11.8.2 Where duplicate nameplates are supplied, they shall comply with **5.10.8.5.1**.

12 PRESSURE VESSELS

Pressure vessels thickness calculations – Example for reference only:

Material of construction : IS 2041 grade R260

762 mm diameter × 3 936 mm straight length

Circumferential stress (longitudinal joints)

$$t = \frac{PR}{SE - 0.6P}$$

where

t = minimum required thickness of shell in (mm);
P = internal design pressure in (kg/cm^2);
R = inside radius of shell course under consideration, in (mm);
S = maximum allowable stress value of materials in (kg/cm^2); and
E = joint efficiency for, or efficiency of, appropriate joint in cylindrical or spherical shells, or the efficiency of ligaments between openings, whichever is less.

'E' for (Efficiency)

DP test = 0.7
Spot X ray = 0.85
100 % X ray = 1.00

Thickness calculation for low pressure (L.P.) vessel

Sl No. (1)	*Item* (2)	*Value* (3)	*Unit* (4)
i)	P	21.1	kg/cm²
ii)	R	381	mm
iii)	S	1 230.4	kg/cm²
iv)	E	0.7	%

$$t = \frac{8\,039.1}{848.62}$$

$$t = 9.47 \text{ mm}$$

Add corrosion allowance of 1.5 mm

T = 10.97 mm

Use next higher size plate available i.e. 12 mm

Formed Head (Ellipsoidal) Thickness Calculations

Material of construction (MOC): IS 2041 grade R260

The required thickness of plate will be as per formula given below:

Circumferential stress (longitudinal joints)

$$t = \frac{PD}{2SE - 0.2P}$$

where

t = minimum required thickness of head after forming, in (mm);
P = internal design pressure, in (kg/cm^2);
D = inside diameter of the head skirt; or inside length of the major axis of an ellipsoidal head; or inside diameter of a conical head at the point under consideration, measured perpendicular to longitudinal axis;
r = inside knuckle radius;

S = maximum allowable stress value in tension as given in (kg/cm^2);

E = lowest efficiency of any joint in the head; for hemispherical heads this includes head-to-shell joint; for welded vessels, use the efficiency specified

‘E’ for (Efficiency)

DP test	=	0.7
Spot X ray	=	0.85
100 % X ray	=	1.00

Thickness calculation for L.P. Vessel – Sample

Sl No. (1)	*Item* (2)	*Value* (3)	*Unit* (4)
i)	P	21.1	kg/cm²
ii)	D	762	mm
iii)	S	1 230.4	kg/cm²
iv)	E	0.7	%

$$t = \frac{16\,078.2}{1\,718.34}$$

t = 0.37 inch

t = 9.35 mm

Add corrosion allowance of 1.5 mm T = 10.85 mm

Use next higher size plate available that is 12 mm

Table 8 Recommended Minimum Thickness for Various Pressure Vessel Sizes (Ready Reckoner)

(*Clause* 12)

Sl No. (1)	**Vessel Diameter in Inches** (2)	**Plate Thickness in mm IS 2041 Grade R260** (3)	**Dishend Thickness in mm IS 2041 Grade R260** (4)
i)	24	10	10
ii)	30	12	12
iii)	36	14	14
iv)	42	16	16
v)	48	18	18

This applies to pressure vessels for use in closed-circuit stationary ammonia refrigerating systems.

12.1 Design

12.1.1 Pressure vessel maximum allowable working pressure (*see* Table 3) shall not be less than the following:

a) High side service utilizing water-cooled, air-cooled, or evaporative condensing — 2 070 kPa gauge; and

b) Low side service — 1 720 kPa gauge.

NOTE — When ammonia liquid is to be transferred from pressure vessels by pressurized ammonia gas, the pressure vessel design pressure shall accommodate the maximum possible transfer pressure and take into account the lowest possible coincident metal temperature.

12.1.2 Pressure vessels exceeding 150 mm inside diameter shall comply with as **5.9.2** covering the requirements for design, fabrication, inspection and testing during construction of unfired pressured vessels.

NOTE — For pressure vessels having inside diameters less than 150 mm, *see* **5.9.2** for ultimate strength requirements.

12.1.3 The relief connection shall be a minimum of three-quarter inch 20 mm for pressure vessels (for example, oil separators) exceeding 150 mm inside diameter and a minimum of 25.4 mm for pressure vessels 10 mm cubic feet in volume or larger.

12.1.4 Pressure vessels shall be provided with adequate opening(s) for the attachment of pressure relief device(s) as required in **15.3.2**.

12.1.5 The heads and shell of pressure vessels shall be hot formed or stress relieved after cold-forming.

NOTE — It is recommended that high-side vessels receive post-weld heat treatment per Annex D (Informative).

12.1.6 A vessel shall be designed and stamped with a minimum design metal temperature (MDMT) no higher than its lowest expected operating temperature.

12.1.7 In applications where vessels are subject to external corrosion, the vessels shall be designed and specified with a minimum of 1.6 mm corrosion allowance.

12.1.8 It shall be determined that the pressure vessel is piped for the pressure and temperature limitations as specified on the nameplate data.

12.1.9 All pressure vessels should be designed as per this standard (*see* **5** and **12**).

12.2 Procedures/Testing

Pressure vessels shall be strength tested at a pressure 1.5 times the design pressure, and leak tested and proven tight at a design pressure pneumatically (dry air/dry nitrogen) by the manufacturer.

12.3 Equipment Identification

12.3.1 Manufacturers producing pressure vessels shall provide data in accordance with the requirements of the relevant as per **5.10.8.5.1**, but in any case shall provide the following minimum data on a metal nameplate affixed to the equipment as specified in **12.3.2**:

a) Manufacturer’s name (preceded by the words “certified by”);

b) Maximum allowable working pressure at temperature;

c) Minimum design metal temperature at pressure;

d) Manufacturer's serial number;

e) Year of manufacture;

f) Model number (where applicable);

g) Test pressure (note test type; hydraulic or pneumatic);

h) Type of construction (in accordance with this standard); and

j) A stamp shall be affixed to the equipment that includes the minimum design metal temperature (MDMT) that it is operated at in accordance to this standard.

12.3.2 *Nameplate Mounting*

12.3.2.1 The original nameplate shall be affixed to the equipment as specified as per **5.10.8.5.1**.

12.3.2.2 Where duplicate nameplates are supplied, they shall comply with **5.10.8.5.1**.

12.3.2.3 If any pressure vessel is insulated, the nameplate shall be mounted on an approved stand-off so it is not covered or the insulation at the nameplate location on the pressure vessel shall be removable to allow for nameplate inspection.

12.4 Pressure Vessels Installation Considerations

Regardless of location, the common considerations and the site specific considerations must be addressed when installing pressure vessels.

12.4.1 Consideration shall be given for proper clearance for maintenance and physical protection. *See* **7.1.1**.

12.4.2 Pressure vessels supported from the ground shall rest on a concrete or other approved housekeeping pad base and/or shall come with an approved support for sitting directly on and anchoring to the foundation.

12.5 Alarms and Detection

Pressure vessels located indoors in areas outside the machinery room shall use at a minimum, level 2 detection. *See* **17.6**.

13 PIPING

This applies to piping for use in closed-circuit stationary ammonia refrigerating systems:

a) Liquid, vapour, discharge and hot gas lines carbon steel pipe must be as per Table 9;

b) Couplings, elbows and tees for threaded pipe should be minimum 2 100 kPa design pressure and constructed of forged steel;

c) Tongue and groove flanges should be used for piping, welded joints are preferred;

d) Low side piping should be designed for 1 720 kPa design pressure and high side should be designed for 2 070 kPa for water cooled condensing with evaporative or shell and tube condensers. Use 2 760 kPa minimum for air cooled design;

e) Use long radius welded elbows and butt-welded fittings on 50 mm and larger pipe (as per table 4) to all liquid lines; and

f) Use a minimum of bolted flanged joints. If essential use tongue and groove joint. Use seal caps on all valves which are not manually operated on a regular basis.

NOTE — No impact test is required for ferrous materials used in fabricating or piping system for metal temperatures between -29°C and -101°C provided the maximum circumferential or longitudinal tensile stress resulting from coincident pressure, thermal contraction or bending between supports does not exceed 40 percent of allowable stress for the material.

Table 9 Velocity Requirement for Line Sizing

(*Clause* 13)

Sl No.	Line Location	Velocity (m/sec)
(1)	(3)	(3)
i)	Suction line (NH_3)	15.0-17.5
ii)	Discharge line (NH_3)	17.5-20.0
iii)	Liquid line (NH_3) condenser to receiver	0.5-0.6
iv)	Liquid line (NH_3) receiver to system	1.0-1.5
v)	Wet return line (NH_3)	8.0-10.0
vi)	Suction line (H_2O)	1.0-1.2
vii)	discharge line (H_2O)	2.0-2.5

13.1 Carbon Steel Pipes Threaded

All threaded pipe will be as per Table 4. Threaded joints are allowed only up to 40 NB.

13.2 Stainless Steel, Welded

13.2.1 Refer Tables 5 and 7 for weld joints.

13.2.2 Refer Table 4 for threaded joints. Threaded joints are allowed only up to 40 NB.

13.2.3 Pipe shall be new, clean and free of rust, scale, sand, debris and dirt, both internally and externally.

13.2.4 *Location of Refrigerant Piping*

13.2.4.1 Refrigerant piping crossing an open space that affords passageway shall not be less than 2.2 m above the floor unless the piping is located against the ceiling of such space.

13.2.4.2 Passages shall not be obstructed by refrigerant piping. Refrigerant piping shall not be placed in any elevator, dumbwaiter, or other shaft containing a moving object, or to in any way hinder means of egress.

13.2.4.3 Refrigerant piping shall not be installed in an unrestricted (for example, approved site public visitors, guests, or vendors could use) stairway, stair landing, or means of egress.

13.2.4.4 All ammonia piping shall be properly protected for the area it is installed from physical or environmental damage. *See* **7.1** common considerations.

13.2.4.5 Installing refrigerant piping underground is not prohibited. Any such piping installed underground shall be protected against corrosion.

13.2.4.6 Stop valves shall be installed in the refrigerant piping of a refrigeration system at the following locations:

a) At the inlet and outlet of a positive-displacement -type compressor, compressor unit, or condensing unit;
b) At the main feed inlet(s) and outlet(s) of individual refrigeration equipment loads; and
c) At the refrigerant inlet and outlet of a pressure vessel containing liquid refrigerant and having an internal gross volume exceeding three (3) cubic feet (0.085 cubic metres).

13.3 Refrigerant Valves

This applies to the equipment and system design requirements for valves used in the ammonia-containing and the lubricant-containing parts of closed-circuit ammonia refrigerating systems.

NOTE — Valves within the refrigerant-containing envelope of other equipment such as slide valves in screw compressors; safety relief valves.

13.3.1 *Valves in Equipment and System Design*

13.3.1.1 Valves shall be oriented in accordance with the respective manufacturer’s specification.

NOTE — The equipment and system design drawing(s) shall clearly show the following:

a) The required valve orientation in all cases where normal fluid flow through the valve is opposite to the flow direction marking; and
b) The required valve spindle/stem orientation where a specific orientation is necessary for proper operation of the system.

13.3.1.2 Valve gasket materials shall match valve manufacturer’s specifications and be of the thickness specified. Flange bolts shall be tightened in accordance with **13.5.2**.

13.3.1.3 Operating speed of control valve actuators shall be considered in the system design.

13.3.1.4 The de-energized mode of control valves shall be considered in system design.

13.3.2 Check valves installed upstream of other automatic valves have the potential to trap liquid. Provision for hydrostatic relief and liquid removal, to facilitate maintenance, shall be located downstream of the check valve (*see* **15.5)**.

13.3.3 Strainers shall be fitted with provision for refrigerant removal to facilitate maintenance.

13.3.4 Shut-off valves used to isolate equipment, control valves, controls or other components from other parts of the system for the purpose of maintenance or repair shall be capable of being locked out.

NOTE — Control valves and other valves without a manually operable and lockable actuating element intended to stop flow for isolation purposes are not shut-off valves.

For example, solenoid valves, check valves.

13.3.5 Stop valves connecting refrigerant-containing parts to atmosphere shall be capped, plugged, blanked, or locked closed during shipping, testing, operating, servicing, or standby conditions if they are not in use.

13.3.6 Valves required for system emergency shutdown procedure(s) shall be readily accessible and appropriately identified (*see* **5.10.4**).

13.4 Piping Hangers and Supports

13.4.1 Piping hangers and supports shall carry the weight of the piping, as well as any other anticipated loads.

For example, refrigerant weight; insulation; frost/ice; seismic/wind loads; etc.

13.4.2 Sway bracing shall be included where necessary.

13.4.3 Anchors, their attachment points, and methods shall be sufficient to bear all loads.

13.4.4 For piping that is insulated, supports shall be designed and/or the insulation shall be selected to avoid damage to the insulation from compression.

13.5 Piping Fabrication and Assembly

Valves (or flange sets) with specialized tightening requirements shall be installed according to manufacturer’s instructions.

13.5.1 Piping joints shall be assembled and in alignment such that they do not induce distortion and stress and shall be in accordance with the assembly requirements.

13.5.2 *Flanges*

13.5.2.1 The mating surfaces of the gasketed joints shall be parallel, aligned and perpendicular to the pipe axis, in good condition and free of debris and corrosion.

13.5.2.2 Gaskets shall be correctly dimensioned for the flange set.

13.5.2.3 Nuts, bolts, cap screws, and washers shall meet manufacturer's requirements for the application. Bolt threads shall extend completely through the mating nut.

13.5.2.4 The fasteners shall be progressively tightened in a diametrically staggered (crisscross or star) pattern.

13.5.2.5 All threaded pipe will be as per Table 5. Threaded joints are allowed only upto 40NB.

13.5.2.6 Threaded joints shall be adequately supported.

13.5.3 Special care shall be taken during fabrication and assembly to assure that the inside of the piping system is free of contaminants and stays free of contaminants.

13.5.3.1 Pipe and system components shall be properly stored during staging and installation to prevent contaminants from getting inside the system.

13.5.3.2 Cutting and welding procedures shall be used that keep the inside of the piping system free of contaminants.

13.5.4 *Service Provisions*

13.5.4.1 All serviceable components of the refrigerating system shall be so installed that they can be safely serviced (*see* **5.8**).

13.5.4.2 All serviceable components of the refrigerating system shall have hand isolation valves in practical locations (*see* **5.8**).

14 PACKAGED SYSTEMS AND COMPONENTS

This applies to the safe and efficient design, fabrication, and installation of packaged closed-circuit ammonia refrigerating systems and/or components of a system. These packages may or may not be enclosed (*see* **3.52** and **5.10.9**).

Packaged systems are self-contained refrigeration equipment consisting of compressor, condenser, receiver, evaporators and suitable expansion device.

14.1 General

14.1.1 This clause is not intended to supersede the requirements for a machinery room even when the package is installed in a machinery room.

14.1.2 The refrigeration equipment and components shall be laid out on the package to provide proper clearances for the safe and efficient service, maintenance, component replacement and operation per manufacturer's requirements, when the package is installed.

14.1.3 Equipment, components and piping installed as part of a package shall be located in such a manner as to allow safe egress from any part of the package in the event of an emergency.

14.1.4 Packages that are enclosed at point of fabrication or after installation shall be vented for the proper operation of the equipment and for emergency ventilation in case of an ammonia leak.

14.1.5 Packages enclosed or not enclosed shall take into account the installation considerations of this standard.

14.2 Design

14.2.1 The structure of the package shall be properly designed to hold the operating weight of all the equipment and components. If the package is enclosed and installed outdoors the structure shall be designed for snow, wind, and seismic requirements in which it will operate.

14.2.2 The structure of the package shall be designed for the stresses caused by shipping and rigging required to get the package to the site and in place for installation. Temporary supports and bracing may be used. Rigging instructions shall be provided to accommodate the design of the structure.

14.2.3 The structure of the package shall be designed to allow for any loads and/or stresses that will be imposed on the package after installation and start-up. The installed design shall prevent excessive noise and/or vibration or shall be investigated and corrected.

14.2.4 The physical dimensions of the package shall meet the requirements of shipping as well as limitations of installation.

14.2.5 Packaged equipment shall have pump out connections with valve for removal of ammonia.

14.2.6 Consideration shall be made to account for the impact on the packaged equipment and components if operating in low ambient temperatures to avoid condensation of refrigerant in the packaged equipment or piping during operation or standby. The package shall be designed for use in the lowest ambient temperatures expected in which it will operate.

14.2.7 Consideration shall be given to account for the impact on the packaged equipment and components if operating in high ambient temperatures to avoid overheating of equipment or components. The package shall be designed for use in the highest ambient temperatures expected in which it will operate.

14.2.8 The package shall be designed to be protected in the environment it is installed.

14.2.9 All manually operated valves shall be accessible. Isolation valve(s) identified as being part of a system emergency shutdown procedure(s) shall be directly operable or chain-operated from a permanent work surface (*see* **5.10.4**).

14.2.10 Pipes (where applicable) shall be labeled *see* **5.10.5**.

14.2.11 Equipment shall be labeled, *see* **5.10.6**.

14.2.12 Packages shall be equipped with lighting or installed in locations with light fixtures that provide a minimum of 320 lumens/m^2 (30 ft-candles) at the working level of 0.9 m above the floor or platform.

14.2.13 Enclosed packages that require entrance for service, maintenance, inspection or operation shall have lighting control located at entrances. If continuous lighting exists, the lighting control does not need to be located at the entrances.

14.2.14 Enclosed packages that require entrance shall be equipped with ammonia detection.

14.2.15 Pressure vessels incorporated into packaged systems or components shall comply with **12**.

14.3 Fabrication

14.3.1 All equipment shall be set on the package to meet manufacturer's recommendations including proper support and clearances.

14.3.2 All components and piping shall be properly supported to allow for transporting and rigging. Temporary supports and bracing may be used.

14.3.3 Stationary or temporary rigging points shall be provided as required to position the package.

14.3.4 All ammonia piping materials and installation shall meet the requirements of this standards.

14.3.5 All piping and components shall be adequately spaced to allow for insulation as required.

14.3.6 Piping shall be properly pressure tested after fabrication and any leaks repaired. The package shall be shipped with a holding charge of dry nitrogen.

14.3.7 Electrical equipment and wiring shall be installed in accordance with the *Indian Electricity Rules*.

14.3.8 Gas fuel devices and equipment used with refrigerating systems in the package shall be installed in accordance with approved safety standards.

14.4 Installation

Installation of the system or components shall be in accordance with this standard, manufacturer's recommendations and other applicable standards or codes.

15 OVER PRESSURE PROTECTION DEVICES

This applies to pressure relief devices installed on stationary closed-circuit ammonia refrigerating systems for the purpose of relieving excess pressure due to abnormal conditions or fire.

15.1 Pressure Relief Devices

15.1.1 Every closed-circuit ammonia refrigerating system shall be protected by a pressure relief device in accordance with IS 16678 (Part 2)/ISO 5149-2. Pressure relief valves to comply with design requirements against ISO 4126-1. Fusible plugs are not allowed to be used in the system

15.1.2 The system design shall provide for all pressure relief devices to be installed as nearly as practicable directly to the pressure vessel or other parts of the system protected thereby, so that they are accessible for inspection and repair.

15.1.3 All pressure relief devices shall be connected at the highest practical point on the pressure vessel or other parts of the system protected thereby, but in any case above the highest anticipated liquid refrigerant level.

NOTE — For hydrostatic pressure relief, *see* **15.5**.

For oil drain pots and similar applications, connect at the highest point on the vessel.

15.1.4 Relief valves shall not be located in refrigerated spaces unless precautions are taken to prevent moisture migration into the valve body or relief vent line.

15.1.5 The seats and discs of pressure-relief devices shall be constructed of suitable material to resist refrigerant corrosion or other chemical action caused by the refrigerant. Seats and discs shall be limited in distortion, by pressure or other cause, to a set pressure change of not more than 5 percent in a span of five years.

15.1.6 *Setting of Pressure Relief Devices*

15.1.6.1 *Pressure relief valve setting* — All pressure relief valves shall be set to start to function at a pressure minimum 10 percent lower than the design pressure of the parts of the system protected. Refer to Tables 10 and 11.

15.1.6.2 *Rupture member setting* — All rupture members used in series with a relief valve shall have a nominal rated rupture pressure not to exceed the design pressure of the parts of the system protected. The conditions of application shall conform to the requirements.

15.1.6.3 Provision shall be made to detect pressure build up between the rupture member and the relief valve due to leakage through the upstream relief device.

15.1.7 *Marking of Relief Devices*

15.1.7.1 All pressure relief valves for refrigerant containing components shall be set and sealed by the manufacturer. Each pressure relief valve shall be marked by the manufacturer with the data. If a pressure relief valve requires resetting, this shall be undertaken by the manufacturer or a company holding a valid testing certificate for this work.

15.1.7.2 Each rupture member for refrigerant containing pressure vessels shall be marked with the data required.

15.1.7.3 Capacity in standard cubic feet per minute [SCFM] (cum/sec) or in kg air/min (lb air/min) at 15°C shall be stamped on device or available on request.

15.2 Pressure Relief Protection

15.2.1 Pressure vessels and other types of equipment built and stamped in accordance shall be provided with pressure relief protection in accordance with standard.

15.2.2 Pressure vessels intended to operate completely filled with liquid refrigerant and are capable of being isolated by stop valves from other parts of a closed-circuit ammonia refrigerating system shall be protected with a liquid service relief device *see also* **15.5**.

15.2.3 Pressure relief devices shall be sized in accordance with **15.2.7**.

15.2.4 Pressure vessels less than 0.3 m^3 internal gross volume shall be protected by one or more pressure relief devices.

15.2.5 Pressure vessels of 0.3 m^3 or more internal gross volume shall be protected by at least one of the following options:

15.2.5.1 *One or more dual pressure relief device(s)*

Dual pressure relief valves shall be installed with a three-way valve to allow testing or repair. When dual relief valves are used, each valve must meet the requirements of **15.2.7**. When multiple dual relief valve assemblies are used the following shall apply:

15.2.5.1.1 The sum of the capacities of the pressure relief devices actively protecting the vessel must equal or exceed the requirements of **15.2.7**.

15.2.5.1.2 The dual relief valve(s) shall be set to a fully seated position (one side open and one side closed).

15.2.5.2 A single pressure relief device, provided that: the vessel can be isolated and pumped out; the relief valves are located on the low side of the system; and other pressure vessels in the system are separately protected in accordance with **15.2.7**.

15.2.6 When pressure relief valves are discharged into other parts of the closed-circuit ammonia refrigerating system, the system shall be equipped with pressure relief devices capable of discharging the increased capacity in accordance with **15.2.7** and the pressure relief valves discharging into the system shall be either:

a) A type not appreciably affected by back pressure; or

b) A type affected by back pressure, in which case its set pressure added to the set pressure of the system pressure relief device shall not exceed the maximum allowing working pressure of any component being protected and shall comply with the following:

   1) The pressure relief valve that protects the higher pressure vessel shall be selected to deliver capacity in accordance with **15.2.7** without exceeding the maximum allowable working pressure of the higher pressure vessel accounting for the change in mass flow capacity due to the elevated back pressure;

   2) The capacity of the pressure relief valve protecting the part of the system receiving a discharge from a pressure relief valve protecting a higher pressure vessel shall be at least the sum of the capacity required in **15.2.7** plus the mass flow capacity of the pressure relief valve discharging into that part of the system; and

   3) The design pressure of the body of the relief valve used on the higher pressure vessel shall be rated for operation at the design pressure of the higher pressure vessel in both pressure containing areas of the valve.

15.2.7 *Pressure Relief Device Capacity Determination*

15.2.7.1 Pressure relief devices shall have sufficient mass flow carrying capability (capacity) to limit the pressure rise in a protected component to prevent its catastrophic failure.

The minimum required relief capacity shall depend on the component being protected and the scenarios under which overpressure is being created.

NOTE — Metric formula as cum/m × 1.204 = kg/min of dry air.

Table 10 Safety Valve Capacity (Air) in kg/h for High Pressure Receivers

(*Clause* 15.1.6.1)

Design pressure 21 bar (2 100 kPa gauge)

Safety valve set pressure 19 bar (1 900 kPa gauge)

Sl No.	Diameter in mm	Length in mm	Safety Valve Capacity (Air) kg/h
(1)	(2)	(3)	(4)
i)	508	2 743	200.67
ii)	508	3 658	267.56
iii)	508	4 877	356.75
iv)	610	4 877	428.10
v)	762	4 877	535.12
vi)	762	6 096	668.90
vii)	914	6 096	802.68
viii)	1 016	6 096	891.87
ix)	1 219	6 096	1 070.24
x)	1 372	6 096	1 204.02
xi)	1 524	6 096	1 337.80
xii)	1 778	6 096	1 560.77

Table 11 Safety Valve Capacity (Air) in kg/h for Low Pressure Receivers

(*Clause* 15.1.6.1)

Design pressure 21 bar (2 100 kPa gauge)

Safety valve set pressure 16.8 bar (1 680 kPa gauge)

Sl No.	Diameter in mm	Length in mm	Safety Valve Capacity (Air) kg/h
(1)	(2)	(3)	(4)
i)	762	3 658	401.34
ii)	914	3 658	481.61
iii)	1 016	2 438	356.75
iv)	1 016	3 048	445.93
v)	1 219	3 048	535.12
vi)	1 372	3 658	722.41
vii)	1 372	4 877	963.22
viii)	1 524	4 877	1 070.24
ix)	1 778	4 877	1 248.62

15.2.7.2 The following scenarios shall be considered when determining the pressure relief device capacity for refrigerant containing components. It is permissible to use manufacturer's data when determining relief requirements. All applicable scenarios shall be considered and the capacity of the pressure relief device shall be based on the scenario with the largest capacity requirements:

a) Overpressure due to external fire:

   1) Pressure vessels

The required discharge capacity of a pressure relief device for each pressure vessel shall be determined by the following equation:

$$C = f\,D\,L\ [\text{kg/s}]$$

where

C = required discharge capacity of the relief device, air kg/s;

f = capacity factor of the relief device which is 0.04 for ammonia;

[0.04 is in International System of Units (SI)]

D = outside diameter of vessel, m; and

L = length of vessel, m.

When one pressure relief device is used to protect more than one pressure vessel, the required capacity shall be the sum of the capacities required for each pressure vessel.

   2) Oil separators

The required discharge capacity for each oil separator shall be determined by the following equation:

$$C_{\text{r,os}} = f\,D\,L\ [\text{kg/s}]$$

where

$C_{\text{r,os}}$ = required discharge capacity of the relief device, air kg/s;

f = capacity factor of the relief device which is 0.04 for ammonia;

D = outside diameter of the oil separator, m; and

L = length of the oil separator, m.

   3) Plate heat exchangers

The capacity of the pressure relief device for plate heat exchangers shall be based on the largest projected area of the exchanger using the following equation:

$$C_{r,\text{Plate}}\ HX = f \cdot \sqrt{L2 + W2 \cdot H}\ [kg/s]$$

where

$C_{\text{r,plate}}\ HX$ = Minimum required relief device capacity for plate heat exchanger kg/s;

f = relief device capacity factor which is 0.04 for ammonia;

L = length of the plate pack m;

W = width of the plate pack m; and

H = Height of the plate pack m.

4) Shell and tube heat exchangers

The capacity of the pressure relief device for shell and tube heat exchangers shall be based on the sum of the capacities required for the heat exchanger and the surge drum (if fitted) as follows:

$$\mathrm{C} = f\ (D_\mathrm{V} L_\mathrm{V} + D_\mathrm{S}\ L_\mathrm{S})\ [\mathrm{kg/s}]$$

where

C = required discharge capacity of the relief device, kg/s;

f = capacity factor of the relief device which is 0.04 for ammonia;

D_V = outside diameter of the main vessel portion of the shell and tube heat exchanger, m;

Lv = length of main vessel portion of the shell and tube heat exchanger, m; and

D_S = outside diameter of the surge drum, m LS = length of the surge drum, m.

5) Product storage tanks

For product storage tanks with cooling jackets, the capacity of the pressure relief device shall be based on the diameter of the storage tank and the height of the cooling jacket as follows:

$$C_{\mathrm{r,tank}} = f \bullet D\ H\ [\mathrm{kg/s}]$$

where

$C_{\mathrm{r,tank}}$ = required discharge capacity of the relief device, kg/s;

f = capacity factor of the relief device which is 0.04 for ammonia;

D = outside diameter of the tank, m; and

H = height of the active portion of the heat exchanger (distance between refrigerant supply and return) m.

b) Potential for overpressure due to blocked outlet:

1) Positive displacement compressor protection, *see* **8.2.1** for pressure relief protection for positive displacement compressors;

2) Oil cooling heat exchangers (Annex B) provides a method for determining capacity for safety relief valves to relieve overpressure due to blocked outlets; and

3) Hydrostatic relief protection, *see* **15.5** describes the situations where hydrostatic relief is required for closed refrigerant circuits.

c) Potential for overpressure due to internal heat load:

Annex B provides a method for determining the capacity for safety relief valves to relieve pressure due to internal heat loads in heat exchangers.

d) Other potential overpressure scenarios:

Evaluate other potential overpressure scenarios as applicable to the specific component being protected.

15.2.8 Although not recommended, when combustible materials are stored within 6.1 m of a pressure vessel, the relief device capacity factor, f, in the formulas above becomes $f = 1.25$ [$f = 0.1$].

15.2.9 The rated discharge capacity of a pressure relief valve shall be determined.

15.2.10 The rated discharge capacity of a rupture member discharging under critical flow conditions shall be determined by the following equations:

$$C = 0.64\ P_1\ d^2\ (\mathrm{lb/min})$$

$$d = 1.25\ (C/P_1\ )^{0.5}\ (\mathrm{in})$$

$$[C = 1.1 \times 10^{-6}\ P_1\ d^2\ (\mathrm{kg/s})]$$

$$[d = 959\ (C/P_1\ )^{0.5}\ (\mathrm{mm})]$$

where

C = rated discharge capacity in lb/min [kg/s] of air;

d = smallest of the internal diameter of the in let pipe, retaining flanges or rupture member in inches [mm];

P_1 = rated pressure (psig) × 1.1 + 14.7 psi; and

[P_1 = rated pressure (kPa gauge) × 1.1 + 101.3 kPa].

There shall be provisions to prevent plugging the piping in the event the rupture member relieves.

15.3 Pressure Relief Device Piping

Relief valve piping that discharges external to the closed-circuit ammonia refrigeration system is not part of the closed-circuit ammonia refrigeration system.

15.3.1 Stop valves shall not be installed in the inlet or outlet piping of pressure relief devices unless procedures specified are followed. If a valve is used, it should be in locked open position with handle removed, so that no one can accidently close the valve. The pressure drop effects of full area stop valves shall be taken into account in the engineering of the relief vent piping system which should freely open to atmosphere, normally at least 5 m above the maximum height of occupied areas.

15.3.2 The opening through all pipe, fittings, and pressure relief devices (if installed), including 3-way valves, between a pressure vessel and its pressure relief valve shall have at least the area of the pressure relief valve inlet. This upstream system shall be such that the pressure drop will not reduce the relieving capacity below that required or adversely affect the proper operation of the pressure relief valve. For compressor vessel connections, *see* **8.2.1**.

15.3.3 The pipe size should be 150 mm (6″) and 200 mm (8″). The relief piping shall comply with the material requirements.

15.3.4 The size of the discharge pipe from a pressure relief device shall not be less than the outlet size of the pressure relief device. The size and maximum equivalent length of common discharge piping downstream from each of two or more relief devices shall be governed by the sum of the discharge capacities of all the relief devices that are expected to discharge simultaneously, at the lowest pressure setting of any relief device that is discharging into the piping, with due allowance for the pressure drop in all downstream sections.

15.3.5 Where piping in the system and other components required to comply with this section may contain liquid refrigerant that can be isolated from the system during operation or service, **15.4** shall apply.

15.3.6 Relief piping is intended for relieving only vapour from refrigerant relief valves. It is not permitted to use the relief piping system for the discharge of hydrostatic relief devices and any other fluid discharges (for example, secondary coolants, oil, etc).

15.3.7 Discharge piping shall be supported as per the provisions of **13.4**.

15.4 Discharge from Pressure Relief Devices

15.4.1 *Atmospheric Discharge (Preferred Method)*

Pressure relief devices shall discharge vapour directly to the atmosphere (outdoors) provided that an engineering analysis, demonstrates that fire, health or environmental hazards will not result from atmospheric release of ammonia. In lieu of relieving directly to atmosphere, the following methods of discharging ammonia from pressure relief devices shall be permitted:

a) Discharge through a treatment system;
b) Discharge through a flaring system (*see* **15.4.1.7**);
c) Discharge through a water diffusion system in accordance with **15.4.2**; and
d) Discharge using other approved means.

15.4.1.1 The maximum length of the discharge piping installed on the outlet of pressure relief devices discharging to the atmosphere shall be determined by the method in Annex A.

15.4.1.2 Discharge piping from pressure relief devices piped to atmosphere shall have provision for draining moisture from the piping.

15.4.1.3 The extremity of the pressure relief device(s) discharge piping relieved to atmosphere shall be 6.1 m or more from any window, ventilation intake, or personnel exit.

15.4.1.4 The discharge from pressure relief devices to the atmosphere shall not be less than 4.8 m above the adjacent grade or roof level that is within a 6 m. horizontal distance. The termination of the discharge shall be arranged to avoid spraying of refrigerant on persons in the vicinity.

15.4.1.5 The termination point of the vent discharge line shall be made in a manner that prevents foreign material or debris from entering the discharge piping.

15.4.1.6 Discharge piping is permitted to be terminated 2 m above platform surfaces that are occupied only during service and inspection provided that the termination is at least 5 m above the roof.

15.4.1.7 Flaring systems, if installed, shall be tested to demonstrate their safety and effectiveness meets the design requirements as intended.

15.4.2 *Discharge through a Water Diffusion System (Tank of Water)*

The preferred method of discharge is to the atmosphere (*see* **15.4.1**). If discharging through a water diffusion system (into a tank of water) is used, a tank shall be sized for containing 8.3 liters of water for each kilogram of ammonia that will be released in one hour from the largest relief device connected to the discharge pipe. The water shall be prevented from freezing (by a non-chemical means). The discharge pipe from the pressure-relief device shall distribute ammonia in the bottom of the tank but no lower than 10 m below the maximum liquid level. The tank shall contain the volume of water and ammonia without overflowing.

15.5 Equipment and Piping Hydrostatic Overpressure Protection

15.5.1 The manual isolation for any purpose of equipment and piping sub-section(s) shall be undertaken by trained technician(s) taking all necessary precautions to protect against overpressure due to thermal expansion of trapped liquid refrigerant.

15.5.2 Equipment and piping sub-section(s) can be isolated and can trap liquid refrigerant in the isolated section as follows:

a) Automatically during normal operation;
b) Automatically during shut-down (by any means, including alarm or power failure);
c) During planned isolation for standby or seasonal conditions (for example, situations when the valves in the ammonia lines to/from evaporative condensers are closed during cold weather conditions); or
d) From equipment or component fault shall be protected against over pressure due to thermal expansion of trapped liquid refrigerant by either:

    1) A static relief device or check valve relieving to another part of the close-circuit system; or
    2) An expansion compensation device.

If trapping of liquid with subsequent thermal expansion can occur only during maintenance that is, when personnel are performing maintenance tasks – either engineering or administrative controls shall be used to relieve or prevent the overpressure.

15.5.3 Static pressure relief valves shall not be used as shut off valves (*see* **13.3.4)**.

16 INSTRUMENTATION AND CONTROLS

This clause applies to instrumentation and controls installed on closed-circuit ammonia refrigerating systems and components.

16.1 General

16.1.1 Instruments and controls shall be provided to indicate operating parameters of the refrigeration system and components and provide the ability to manually or automatically control the starting, stopping and operation of the system or components. The instruments and controls shall provide notice to a monitored location if the system's critical operating parameters determined by the owner/operator are exceeded.

16.1.2 The function, sequence and operating parameters of each control (if applicable) shall be documented and provided to the owner/operator.

16.1.3 During a power failure, a means to monitor the status of the ammonia concentration levels shall be available.

16.1.4 If it is intended to control safety functions of the system (for example, emergency exhaust, equipment shutdown), the basic control system shall be designed to be separate and independent to the extent that its functional integrity is not compromised during normal operations. For example, changing set points for system operation (for example, temperature, pressure, flow, vessel levels) shall not affect alarm levels.

16.1.5 All electrical control systems must be in compliance with SP 30.

16.2 Visual Liquid Level Indicators

Bull's eyes, tubular glass and flat "armored glass" linear sight glasses/sight columns, pressure gauges.

16.2.1 *Design*

a) Design of refrigerant containing parts shall meet the requirements of at least one of the following:
    1) Be listed either individually or as part of an assembly or a system;
    2) Prove satisfactory by successful performance under comparable service conditions; and
    3) Have a pressure-containment design based on an analysis consistent with the general design philosophy embodied and substantiated by one of the following:
        i) Proof tests as described in **5** and **12**; and
        ii) Experimental stress analysis.

b) Minimum design pressure for visual level indicators shall be 2 070 kPa gauge.

NOTE — For visual level indicators designed specifically for and usable for low side use exclusively, minimum design pressure shall be 1 720 kPa gauge.

16.2.2 All visual liquid level indicators used to observe the refrigerant level, such as in a vessel or heat exchanger, shall be installed in such a manner that they are protected from physical damage.

16.2.3 Accumulators or intercoolers shall be equipped with high level indicator switches which actuate a high level alarm, and where practical, cause the associated compressor(s) to shut down when a high refrigerant level is detected.

16.2.4 Linear liquid level indicators (sight columns) shall be fitted with internal check-type shutoff valves. This type of sight glass shall also have robust protection against accidental breakage 360 degrees around the glass tube, over the full length of the tube.

Liquid-level-gauge columns using bull's-eye type sight glasses are an exception to this.

NOTE — It is recommended that linear visual liquid indicators (sight columns) be of the flat "armored glass" type in preference to the tubular glass type.

16.2.5 Bull's eye sight glasses shall be verified compatible for use with ammonia, and shall be an appropriate thickness for the diameter and type of glass that is used.

16.2.5.1 Bull's eye sight glasses shall be traceable through a serial number or other form of identification in a manner that does not compromise the glass structure or integrity.

16.2.5.2 Sight glasses and linear liquid level indicators shall not be installed in areas subject to cyclic thermal expansion or liquid hammer.

16.3 Controls, Electric and Pneumatic

This applies to sensing devices which initiate control pulses or signals applied for use in ammonia closed-circuit refrigerating systems.

Relay switches, contactors, and starters are not included in this clause.

16.3.1 *Design*

a) Design of refrigerant containing parts shall meet the requirements of at least one of the following:
   1) Be listed either individually or as part of an assembly or a system;
   2) Prove satisfactory by successful performance under comparable service conditions; and
   3) Have a pressure-containment design based on an analysis consistent with the general design philosophy embodied and substantiated by one of the following:
      i) Proof tests as described in **5** and **12**; and
      ii) Experimental stress analysis.

b) Minimum design pressure for control instruments or devices shall be 2 070 kPa gauge.

   NOTE — For controls designed specifically for and usable for low side use exclusively, minimum design pressure shall be 1 720 kPa gauge.

16.3.2 *Procedures/Testing*

16.3.2.1 *Leakage test*

Each completely assembled control shall be subject to a manufacturer's refrigerant side bench test using air or other suitable fluid which will enable observation of leakage. Each control shall be proven tight at a pressure not less than the design pressure for which it is rated.

16.3.2.2 *Functional test*

Each completely assembled control shall be subjected to a manufacturer's bench test which will simulate the field performance of the control in a manner which will determine that the completed device functions as designed or specified.

16.3.3 *Equipment Identification*

16.3.3.1 Manufacturers producing electrical and/or pneumatic controls shall provide the following minimum nameplate data:

a) Manufacturer's name;
b) Manufacturer's serial number (where applicable);
c) Model number;
d) Electric supply: volts, full load amps, frequency (Hz), phase (where applicable);
e) Pneumatic system: control range: maximum supply air pressure, minimum supply air pressure, required actual cubic feet per minute (ACFM), (where applicable);
f) Flow direction (where applicable); and
g) Any special characteristics of a control device shall be noted either on the name tag or in the accompanying literature.

17 AMMONIA DETECTION AND ALARMS

This clause applies to ammonia detection and alarms installed on closed-circuit ammonia refrigerating systems.

17.1 Scope

The requirements given from **17.2** to **17.6** applies to detection in areas containing refrigeration equipment; and does not include detection outdoors, within piping or other system components.

17.2 Power for Detectors and Alarms

The power supply for the refrigerant gas detectors shall be on a dedicated branch circuit. If the machine room equipment power shuts down, the refrigerant gas detection system shall remain on. A trouble signal indicating fault in the power system shall be reported to a monitored location so that corrective action can be taken.

17.3 Testing

17.3.1 The facility shall establish a time schedule for testing of the ammonia detectors and the alarm system. The manufacturer's recommendations shall be followed or modified based on documented experience.

17.3.2 Where no recommendations are provided, these devices shall be scheduled for exercising on an annual basis.

17.4 Detector Placement and Alarms

17.4.1 The detection sensors, or sampling tubes that draw air to the detection sensors, shall be located with consideration for personnel safety and maintenance access. If the room is equipped with an exhaust system, the detection sensors shall be located within the airflow of the ventilation system.

17.4.2 The audible alarm shall provide a sound pressure level of at least 15 dBA above the ambient sound pressure level of the area in which it is installed.

17.4.3 The meaning of each alarm shall be clearly marked by signage near the visual and audible alarms.

17.5 Machinery Rooms

See **6.13** for refrigerant detection in machinery rooms.

17.6 Other Areas

Areas other than machinery rooms that require refrigerant detection per this standard shall adhere to the following requirements:

17.6.1 *Level 1 Ammonia Detection Required*

At least one ammonia detector in the room is required. The detector shall actuate an alarm that reports to a monitored location so that corrective action can be taken at a level no higher than 25 ppm.

17.6.2 *Level 2 Ammonia Detection Required*

At least one ammonia detector in the room is required. The detector shall actuate an alarm that reports to a monitored location so that corrective action can be taken at a level no higher than 25 ppm.

There shall be audible and visual alarms inside the room for the room to warn that when the alarm is activated, access to the room is restricted to authorized, trained personnel only.

17.6.3 *Level 3 Ammonia Detection Required*

At least one ammonia detector in the room is required. The detector shall actuate an alarm that reports to a monitored location so that corrective action can be taken at a level no higher than 25 ppm.

There shall be audible and visual alarms inside the room for the room to warn that when the alarm is activated, access to the room is restricted to authorized, trained personnel only.

Upon alarm, all valves feeding liquid or hot gas to equipment in the affected area shall be closed, and any pumps, fans, or other motors associated with the ammonia refrigeration equipment in the room shall be de energized.

17.6.4 *Level 4 Ammonia Detection Required*

At least one ammonia detector in the room is required. The detector shall actuate an alarm that reports to a monitored location so that corrective action can be taken at a level no higher than 25 ppm.

There shall be audible and visual alarms inside the room for the room to warn that when the alarm is activated, access to the room is restricted to authorized, trained personnel only.

SECTION 4

ANNEX A

(*Clause* 15.4.1.1)

(*Normative*)

ALLOWABLE EQUIVALENT LENGTH OF DISCHARGE PIPING

A-1 ALLOWABLE EQUIVALENT LENGTH OF DISCHARGE PIPING

The design back pressure due to flow in the discharge piping at the outlet of pressure relief devices, discharging to atmosphere, shall be limited by the allowable equivalent length of piping determined by equation 1 or equation 2.

Equation 1: Allowable relief discharge piping length, English units

$$L = \frac{0.2146\, d^5 (P_0^2 - P_2^2)}{fC_r^2} - \frac{d \times \ln\left({P_0}/{P_2} \right)}{6f} \qquad \ldots 1$$

Equation 2: Allowable relief discharge piping length, SI units

$$L = \frac{7.4381 \times 10^{-15}\ d^5 (P_0^2 - P_2^2)}{fC_r^2} - \frac{d \times \ln\left({P_0}/{P_2} \right)}{500f} \qquad \ldots 2$$

where

L = equivalent length of discharge piping, m [ft];

C_r = rated capacity as stamped on the relief device in kg/s, or in standard cubic feet per minute (SCFM) multiplied by 0.076 4, or as calculated in **15.2.7.2**, for a rupture member, or as adjusted for reduced capacity due to piping as specified by the manufacturer of the device, or as adjusted for reduced capacity due to piping as estimated by an approved method;

f = Moody friction factor in fully turbulent flow (*see* typical values below);

d = inside diameter of pipe or tube, in mm;

ln = natural logarithm;

P_2 = absolute pressure at outlet of discharge piping, kPa; and

P_0 = allowed back pressure (absolute) at the outlet of pressure relief device, kPa.

For the allowed back pressure (P_0), use the percent of set pressure specified by the manufacturer, or, when the allowed back pressure is not specified, use the following values, where P is the set pressure:

a) for conventional relief valves, 15 percent of set pressure, $P_0 = (0.15\ P)$ + atmospheric pressure;

b) for balanced relief valves, 25 percent of set pressure, $P_0 = (0.25\ P)$ + atmospheric pressure; and

c) for rupture members and pilot operated relief valves, 50 percent of set pressure, $P_0 = (0.50\ P)$ + atmospheric pressure.

Typical Moody friction factors (f) for fully turbulent flow is given in Table 12 and Table 13:

Table 12 Typical Moody Friction Factors, Steel Tubing Piping (NPS)

(*Clause* A-1)

Sl No.	Piping, Nominal Pipe Size (NPS) (in.)	Nominal Diameter (DN)	Inner Diameter (in.)	*f*
(1)	(2)	(3)	(4)	(5)
i)	3/8	8	0.315	0.013 6
ii)	½	10	0.430	0.012 8
iii)	5/8	13	0.545	0.012 2
iv)	¾	16	0.666	0.011 7
v)	7/8	20	0.785	0.011 4
vi)	1 3/8	25	1.025	0.010 8
vii)	1 3/8	32	1.265	0.010 4
viii)	1 5/8	40	1.505	0.010 1

NOTE — 1 inch = 2.54 cm

Table 13 Typical Moody Friction Factors, Steel Piping

(*Clause* A-1)

Sl No.	Piping Nominal Pipe Size (NPS) (in.)	Nominal Diameter (DN)	Inner Diameter (in.)	*f*
(1)	(2)	(3)	(4)	(5)
i)	½	15	0.622	0.025 9
ii)	¾	20	0.824	0.024
iii)	1	25	1.049	0.022 5
iv)	1	32	1.38	0.020 9
v)	1½	40	1.61	0.020 2
vi)	2	50	2.067	0.019
vii)	2½	65	2.469	0.018 2
viii)	3	80	3.068	0.017 3
ix)	4	100	4.026	0.016 3
x)	5	125	5.047	0.015 5
xi)	6	150	6.065	0.014 9

NOTE — 1 inch = 2.54 cm

ANNEX B

(*Informative*)

METHODS FOR CALCULATING RELIEF VALVE CAPACITY FOR HEAT EXCHANGER INTERNAL LOADS

B-1 INTRODUCTION

This informative Annex presents approaches for determining the capacity of relief valves for overpressure scenarios not explicitly covered in **15**. This information can be used to document a basis for relief device capacity determination for heat exchangers that may be subject to overpressure due to internal heat loads or blocked valves that can lead to high refrigerant pressures. Pressure relief devices need to have sufficient mass flow carrying capability (capacity) to limit the pressure rise in a protected component to prevent its catastrophic failure. The minimum required relief device capacity will depend on the specify component being protected and the scenarios under which overpressure is being created. The maximum relief device capacity is not limited by codes and standards. However, over-sizing relief valves shall be avoided to prevent unstable relief device operation.

Although the methods presented in this informative Annex are intended to apply across a wide range of refrigeration equipment and operating conditions, it is not possible to neatly prescribe relief device sizing and selection criteria to cover all situations. The approach presented here is intended to be illustrative of the process that can be followed in establishing pressure relief requirements for specify situations. As such, the use of sound engineering principles and the application of engineering judgment are expected.

It is important to emphasize that for all of the cases considered, the rate of refrigerant vapour production needs to be converted to an air mass flow since all of the relief devices are rated on an air basis. In the sections that follow are methods for relief capacity determination for different types of heat exchangers based on internal heat addition.

B-2 NOMENCLATURE

$c_{p,fluid}$ = secondary fluid heat capacity, J/kg·K (Btu/lbm-°F);

$C_{pfluid,CIP}$ = clean-in-place fluid heat capacity, J/kg·K (Btu/lbm-ºF);

C_r = minimum required discharge capacity of the relief device for a vessel, kg/s (lbm/min of air);

$C_{r,plate\ HX}$ = minimum required relief device capacity for plate heat exchanger, kg/s (lbm/min of air);

$C_{r,OS}$ = minimum required discharge capacity of the relief device protecting an oil separator, kg/s (lbm/min of air);

$C_{r,tank}$ = minimum required discharge capacity of the relief device protecting a product tank heat exchanger, kg/s (lbm/min of air);

D = outside diameter of vessel or product tank, m (ft);

D_s = outside diameter of surge drum, m (ft);

D_v = outside diameter of the main vessel portion of the shell-and-tube heat exchanger, m (ft);

f = relief device capacity factor that depends on refrigerant type and whether combustible materials are in close proximity to the pressure vessel;

H = height of the plate pack or tank heat exchanger, m (ft);

$h_{vapor,sat}$ = saturated vapour refrigerant enthalpy at the fully accumulated relief device set pressure, J/kg (Btu/lbm);

$h_{liquid,sat}$ = saturated liquid refrigerant enthalpy at fully accumulated relief device set pressure, J/kg (Btu/lbm);

L = length of the vessel or plate pack, m (ft);

$LMTD$ = Log mean temperature difference, °C (°F);

L_s = length of surge drum, m (ft);

L_v = length of the main vessel portion of the shell-and tube heat exchanger, m (ft);

m_{rinem} = secondary fluid mass flow rate, kg/s (lbm/min);

$m_{fluid,CIP}$ = clean-in-place fluid mass flow rate, kg/s (lbm/min);

$m_{refrigerant}$ = refrigerant vapour generation rate, kg/s (lbm/min);

$m_{\text{refrigerant,OC}}$ = mass flow rate of refrigerant vapour generated by the oil cooler, kg/s (lbm/min);

$m_{\text{refrigerant,tank}}$ = mass flow rate of refrigerant vapour generated in a tank heat exchanger, kg/s (lbm/min)

Pr = Prandtl number for fluid used to establish the nominal UA (–);

Pr' = Prandtl number for fluid used to establish the modified UA' (–);

Q = heat exchanger heat flux, W (Btu/min);

Q_{oc} = oil cooling heat exchanger heat load, W (Btu/min);

$T_{\text{fluid,CIP,supply}}$ = maximum fluid supply temperature during CIP, °C (ºF);

$T_{\text{refrigerant}}$ = refrigerant saturation temperature, °C (°F);

$T_{\text{ref,sat}}$ = refrigerant's saturation temperature at the relief valve set pressure, °C (ºF);

T_{return} = load-side heat exchanger secondary fluid return temperature, °C (°F);

T_{supply} = load-side heat exchanger secondary fluid supply temperature, °C (°F);

UA = overall heat transfer coefficient-area product, W/m^2K (Btu/min-°F);

UA' = modified overall heat transfer coefficient area product, W/m^2K (Btu/min-°F);

W = width of the plate pack, m (ft); and

$\acute{\varepsilon}$ = refrigerant-to-product tank effectiveness (estimated as 0.2 for bulk tanks)

The relevant SI units and corresponding conversion factors are given below for guidance:

1°C = 33.8°F

1 m = 3.28 ft

= 39.37 inch

1J/kg/K = $2.388\,460 \cdot 10^{-4}$ BTU/lb/F

1 kg/s = 2.205 lbm/min

1 J/kg = 0.000 43 Btu/lbm

1 W = 0.056 8 Btu/min

1 $W/(m^2 \cdot K)$ = 0.176 2 $Btu/h/ft^2/°F$

1 Pa = N/m^2

= 0.000 145 psig

= 10^{-5} bar

B-3 APPLICATION

If a heat exchanger is built to the requirements of IS 4503 or **5** and **12** of this standard it requires pressure relief protection as per **15**.

In cases where conventional pressure relief protection is not required, it is often desirable to size a suitable "process" relief that will prevent over pressuring the heat exchanger during abnormal operation. The first step in determining the minimum required mass flow for relief protection is defining the scenarios likely to cause the overpressure situation. Heat exchangers are susceptible to over-pressure by internal heat loads from either product or other secondary fluid flow streams (e.g. clean-in-place systems). In either situation, the key consideration for relief device sizing is determining the rate of refrigerant vapour production by evaporation which will be dependent on the heat load and the refrigerant properties (saturation pressure temperature relationship and heat of vapourization).

B-3.1 Shell-and-Tube, Plate and Frame, and Scraped (Swept) Surface Heat Exchangers

Most scenarios involve alternate means of thermal energy input to the heat exchanger when the refrigerant side of the chiller has been isolated from the refrigeration system but the secondary fluid side remains active. Examples of thermal loads that could generate excessive pressure in a shell-and-tube or plate-and-frame heat exchanger may include but are not limited to product loads and clean-in-place (CIP) loads.

Of primary concern are those thermal energy sources whose temperatures that exceed the saturation temperature corresponding to the heat exchanger's maximum allowable working pressure (MAWP) or pressure relief device set pressure. If the maximum fluid-side supply temperature is less than the saturation temperature corresponding to the heat exchanger's MAWP. If the maximum fluid-side temperature is greater than the saturation temperature corresponding to the heat exchanger's MAWP, vapour generation rates based on the "internal loads" shall be estimated to determine if a larger relief device capacity requirement results.

The first step in the process of considering an internal heat load scenario that could generate an overpressure situation is to evaluate the normal capacity of the heat exchanger. The next step is to estimate the heat exchanger's capacity under the adverse load condition and determine the corresponding rate of refrigerant vapour generation. Lastly, the predicted rate of refrigerant vapour generation is converted to an equivalent air mass flow rate to allow relief device selection.

Determining the rate of refrigerant vapour production can be accomplished by solving a system of equations that characterize the equipment heat transfer performance, as given by equation (3), and the balance of both refrigerant-side and fluid-side energy flows as given by equations (4) and (5), respectively. The system of governing equations is as follows:

$$Q = UA.LMTD \qquad \ldots 3$$

$$LMTD = \frac{(T_{return} - T_{refrigerant})}{\ln\left[\dfrac{T_{return} - T_{refrigerant}}{T_{supply} - T_{refrigerant}}\right]} \qquad \ldots 4$$

$$Q = m_{\text{fluid}}.C_{\text{p,fluid}}\,.\,(T_{return} - T_{supply}) \qquad \ldots 5$$

$$Q = \text{m}_{\text{refrigerant}}.(h_{\text{vapor.sat}} - h_{\text{liquid.sat}}) \qquad \ldots 6$$

where

Q = heat exchanger heat flux, W (Btu/min);

UA = overall heat transfer coeffcient-area product, W/m^{2}K (Btu/min-°F);

$LMTD$ = Log mean temperature difference, °C (°F);

T_{return} = load-side heat exchanger secondary fluid return temperature, °C (°F);

T_{supply} = load-side heat exchanger secondary fluid supply temperature, °C (°F);

$T_{\text{refrigerant}}$ = refrigerant saturation temperature, °C (°F);

b_{rinem} = secondary fluid mass flow rate, kg/s (lbm/min);

$C_{\text{p,fluid}}$ = secondary fluid heat capacity, J/kg·K (Btu/lbm-°F);

$m_{\text{refrigerant}}$ = refrigerant vapour generation rate, kg/s (lbm/min);

$h_{\text{vapor,sat}}$ = saturated vapour refrigerant enthalpy at the fully accumulated relief device set pressure, J/kg (Btu/lbm); and

$h_{\text{liquid,sat}}$ = saturated liquid refrigerant enthalpy at fully accumulated relief device set pressure, J/kg (Btu/lbm).

In a liquid-containing heat exchanger, the refrigerant temperature ($T_{\text{refrigerant}}$) is assumed to be the saturation temperature corresponding to the pressure relief device set (opening) pressure. The enthalpy of vapourization ($h_{\text{vapor,sat}} - h_{\text{liquid,sat}}$) for the refrigerant-side energy balance is evaluated at the pressure relief device set pressure as well. The return fluid temperature to the heat exchanger (T_{return}) is estimated based on the load which is a function of the fluid flow rate and return fluid from process, CIP set temperature, etc. The mass flow rate of fluid on the load-side of the heat exchanger ($m_{\text{fluid)}}$ is required as well as the load-side fluid heat capacity ($C_{\text{p, fluid}}$).

The nominal value of the heat exchanger's overall heat transfer-area product (UA) is based on design operating conditions. Equation (3) is used to estimate a nominal or design UA. Once a nominal or design UA is established, it can be adjusted or corrected for use in estimating the refrigerant vapour production rate arising in an overpressure situation. For example, if the fluid-side flow rate would be expected to vary from the design condition, the following relationship based on the Dittus-Boelter turbulent heat transfer correlation could be used to predict a modified UA based on an alternative fluid-side flow rate.

$$UA = UA\cdot\left(\frac{\dot{m}'_{fluid}}{\dot{m}_{fluid}}\right)^{0.8}\cdot\left(\frac{\text{Pr}'}{\text{Pr}}\right)^{0.4} \qquad \ldots 7$$

where

UA = nominal overall heat transfer coefficient area product, W/m^{2}K (Btu/min-°F);

UA' = modified overall heat transfer coefficient area product, W/m^{2}K (Btu/min-°F);

Pr = Prandtl number for fluid used to establish the nominal UA (–); and

Pr' = Prandtl number for fluid used to establish the modified UA' (–).

In addition, equation (7) accommodates changes in working fluids when transitioning from a design load condition to a different working fluid that may arise and create an overpressure situation (e.g. changing from a fluid beverage during load conditions to a CIP solution during clean-up) that forms the basis for sizing pressure relief protection for the heat exchanger.

The above-mentioned known information ($T_{\text{refrigerant}}$, $h_{\text{vapor,sat}}$, $h_{\text{liquid,sat}}$, T_{return}, m_{fluid} , $C_{\text{p,fluid}}$, and UA) can be used to simultaneously solve equations (3), (5), and (6) to find the remaining three unknown variables: $m_{\text{refrigerant}}$, T_{supply}, and Q. The quantity of interest is the refrigerant vapour flow rate, $m_{\text{refrigerant}}$, which represents the mass flow of vapour generated during the overpressure scenario. Once obtained, the resulting refrigerant mass flow rate must then be converted to an equivalent mass flow rate for air using the following relationship:

$$C_r = \dot{m}_{refrigerant} \cdot \frac{C_{air}}{C_{refrigerant}} \cdot \sqrt{\frac{T_{refrigerant} \cdot M_{air}}{T_{air} - M_{refrigerant}}} \qquad \ldots 8$$

The above formula assumes a refrigerant temperature of 9.84 °C (49.7 °F) and an air temperature of 15.85°C (60.53 °F). Values of the constants, C_{air} and $C_{\text{refrigerant}}$, for ammonia are as follows:

C_{air} (Ammonia) = 356

$C_{\text{refrigerant}}$ (Ammonia) = 347

The calculated air mass flow based on the estimated refrigerant vapour mass flow represents the minimum required relief capacity for the internal load scenario.

Example: Scraped (swept) surface heat exchanger

Heat exchanger characteristics for one manufacturer's scraped (swept) surface heat exchanger:

$U \cong 300$ Btu/hr• ft^2 °F
6 ft^2 < A < 14.5 ft^2

150 psig ≤ MAWP ≤ 250 psig

Heat load assumption

Internal Load is created by 160 °F CIP fluid

$$Q = UA \bullet LMTD \cong U \bullet A \bullet (T_{cip} - T_{sat,ref})$$

$$Q = \dot{m}_{refrigerant} \bullet (h_{vapour,sat} - h_{liquid,sat})$$

$$\dot{m}_{ref} = \frac{U \bullet A \bullet (T_{CIP} - T_{sat,ref})}{(h_{vapor} - H_{liquid}) \bullet 60 \dfrac{min}{hr}}$$

Heat exchanger characteristics

U = 300 $Btu/hr\text{-}ft^2$-°F
A = 14.5 ft^2
$MAWP$ = 150 $psig$
[Δh = 488 Btu/lb_m, $T_{sat,ref}$ = 89.6 °F]
T_{CIP} = 160 °F

$$\dot{m}_{ref} = \frac{300 \dfrac{Btu}{hr - ft^2 - °F} \cdot 14.5 ft^2 \cdot (160 - 89.6)°F}{(488)\dfrac{Btu}{lbm} \cdot 60 \dfrac{min}{hr}}$$

$$= 10.5 \frac{lbm}{min} (ammonia)$$

$$\dot{m}_{ref} = 1.314 \cdot 10.5 = 13.8 \left(\frac{lbm}{min}\right)$$

Heat exchanger characteristics

U = 300 $Btu/hr\text{-}ft^2$-°F
A = 14.5 ft^2
$MAWP$ = 250 $psig$
[Δh = 453 Btu/lb_m, $T_{sat,ref}$ = 120.8 °F]
T_{CIP} = 160 °F

$$\dot{m}_{ref} = \frac{300 \dfrac{Btu}{hr - ft^2 - °F} \cdot 14.5 ft^2 \cdot (160 - 120.8)°F}{(453)\dfrac{Btu}{lbm} \cdot 60 \dfrac{min}{hr}}$$

$$= 6.3 \frac{lbm}{min} (ammonia)$$

$$\dot{m}_{ref} = 1.324 \cdot 6.3 = 8.3 \left(\frac{lbm}{min}\right)$$

B-3.2 Oil Cooling Heat Exchangers

Over-pressurization can occur when a thermo siphon oil-cooled screw compressor package is started while the refrigerant-side of the oil cooler is isolated (valve out). In this case, the compressor will operate and reject heat to the oil cooler resulting in an increasing supply oil temperature back to the compressor over time. As the compressor continues to operate and reject a portion of its heat of compression through its oil to the oil cooling heat exchanger, a point will be reached when the on-board compressor safeties shutdown the unit on high oil temperature. A typical screw compressor package high oil temperature cutout is approximately 96°C. The saturation pressure corresponding to a refrigerant temperature equal to the oil at its high temperature cut-out of 96°C is 57.69 kg/cm^2 for ammonia. Since this pressure is significantly greater than the oil cooling heat exchanger's maximum allowable working pressure, the oil cooler will be subject to overpressure under this scenario.

The mass flow rate of refrigerant vapour generated on the refrigerant-side of an oil cooler in an overpressure situation is given by:

$$\dot{m}_{refrigerant,OC} = \frac{Qoc}{(h_{vapor,sat} - h_{liquid,sat})} \qquad \ldots 9$$

where

Q_{OC} = oil cooling heat load generated by the compressor operating at design suction pressure and discharge pressures with a corresponding supply oil temperature at the compressor high temperature cut-out limit, W (Btu/min);

$m_{\text{refrigerant,OC}}$ = mass flow rate of refrigerant vapour generated by the oil cooler, kg/s (lbm/min);

$h_{\text{vapor,sat}}$ = saturated vapour refrigerant enthalpy at the fully accumulated relief device opening pressure, J/kg (Btu/lbm); and

$h_{\text{liquid,sat}}$ = saturated liquid refrigerant enthalpy at the fully accumulated relief device opening pressure J/kg (Btu/lbm).

The best source for determining the overpressure condition oil cooling loads, Q_{OC}, is by information provided from the compressor manufacturers. Some compressor manufacturers' computerized selection programs provide this information based on users inputting the design suction and discharge pressures along with oil supply temperatures. The programs return the resulting oil cooling load under the modified (high oil supply temperature) conditions. The oil cooling load imposed on the oil coolers can be evaluated at these modified conditions or alternatively, the full oil cooling load can be taken for sizing the relief device.

The resulting oil cooling load at the elevated operating condition (Q_{OC}) can then be used to estimate the refrigerant mass flow rate using equation (9). The refrigerant mass flow rate is then converted to an air basis using equation (8); thereby permitting the selection of a relief device.

B-3.3 Product Storage Tanks

The scenario for refrigerant vapour generation in the heat exchanger due to internal loads arises during clean-in-place.

The rate of refrigerant vapour generation during clean-in-place can be estimated as follows:

$$\dot{m}_{refrigerant,tank} = \frac{\varepsilon \cdot \dot{m}_{fluid,CIP} \cdot cp_{fluid,CIP} \cdot (T_{fluid,CIP,supply} - T_{ref,sat})}{(h_{vapor,sat} - h_{liquid,sat})} \qquad \ldots 10$$

where

$m_{\text{refrigerant,tank}}$ = mass flow rate of refrigerant vapour generated in the heat exchanger (lbm/ min);

ε = refrigerant to product tank effectiveness (estimated as 0.2);

$m_{\text{fluid,CIP}}$ = CIP fluid mass flow rate, kg/s (lbm/min);

$c_{\text{pfluid,CIP}}$ = CIP fluid heat capacity, W/m^{2}K (approximated as 1 Btu/lbm-ºF);

$T_{\text{fluid,CIP,supply}}$ = maximum fluid supply temperature during CIP, °C (ºF);

$T_{\text{ref,sat}}$ = refrigerant's saturation temperature at the relief valve set pressure, °C (ºF);

$h_{\text{vapor,sat}}$ = saturated vapour refrigerant enthalpy at fully accumulated relief device set pressure, J/kg (Btu/lbm); and

$h_{\text{liquid,sat}}$ = saturated liquid refrigerant enthalpy at fully accumulated relief device set pressure, J/kg (Btu/lbm).

After determining the refrigerant mass flow rate, the relief device capacity (on an air-equivalent basis) is found by using equation (8). The greater of these two capacities forms the basis for relief device selection for a product tank.

A typical set point value and tolerance for a 2 068 kPa gauge (300 psig) system is given below:

Sl No.	*Set Point Value and Tolerance*	*Pressure, in kPa Gauge*	*Pressure, in psig*
(1)	(2)	(3)	(4)
i)	Relief full open (+ 10 percent)	2 275	330
	+ 3 percent tolerance	2 130	309
ii)	Relief valve point	2 068	300
	–3 percent tolerance	2 006	291
iii)	Potential seep point (–10 percent)	1 861	270
	EPCS set point (EPCS set point is equal or below the seep point)	1 724 to 1 862	250 to 270
iv)	Design system operating pressure (–25 percent)	1 551	225
	(System operating pressure should 25 percent lower than the relief valve setting when selecting relief valves)		
	Compressor off-set point	1 551	225

A typical set point value and tolerance for a 7 124 kPa (250 psig) system is given below:

Sl No. (1)	*Set Point Value and Tolerance* (2)	*Pressure, in kPa Gauge* (3)	*Pressure, in psig* (4)
i)	Relief full open (+ 10 percent)	1 896	275
	+ 3 percent tolerance	1 775	257.5
ii)	Relief valve point	1 724	250
	–3 percent tolerance	1 672	242.5
iii)	Potential seep point (–10 percent) (EPCS set point is equal or below the seep point)	1 862	270
	EPCS set point	1 448 to 1 552	210 to 225
iv)	Design system operating		
	pressure (–25 percent)	1 379	200
	(System operating pressure should 25 percent lower than the relief valve setting when selecting relief valves)		
	Compressor off-set point	1 379	200

ANNEX C

(*Informative*)

DUPLICATE NAMEPLATES ON PRESSURE VESSELS

C-1 DUPLICATE NAMEPLATES ON PRESSURE VESSELS

Duplicate nameplates may be desirable in certain circumstances, especially where the original nameplate may be obscured by insulation. Duplicate nameplate can be made as per **5.10.8.5.1**.

Experience has shown that attempting to access the original nameplate for inspection through windows, removable insulation sections, stanchion mounting, etc. tends to compromise the integrity of the insulation system. Moisture ingress into the insulation system follows, with possible damage to the pressure vessel. The use of duplicate nameplates helps prevent vessel damage from inspection ports and other deliberate damage to insulation.

Unfortunately, using duplicate nameplates creates the possibility that the wrong (duplicate) nameplate will be applied to a vessel. While the easiest way to accomplish this is for the manufacturer to weld the nameplate to a support or other permanent vessel appurtenance that will not be insulated, field installation is also permitted. (Some inspection authorities consider the insulation jacket as a permanent attachment to the vessel, and therefore the duplicate nameplate may be applied to the jacket.) The manufacturer's procedures for ensuring a proper match of duplicate to original must be rigorously followed. It is advisable to record the location of the original nameplate should inspection be necessary.

Various inspection authorities, such as state vessel inspectors may demand to inspect and/or approve the duplicate and original nameplates before insulation is applied. While many inspection bodies will accept a duplicate nameplate as evidence compliance for an insulated vessel, authorized inspectors may always demand to inspect the original vessel, including its nameplate. In particular, when the inspector is concerned about the physical condition of the vessel or questions the provenance of the duplicate nameplate, he or she may require the entire insulation system or any part to be removed to permit inspection. Damage to the insulation system must be promptly and professionally repaired, and due allowance should be made for the shorter service life of the repaired insulation system.

ANNEX D

(*Informative*)

STRESS CORROSION CRACKING

D-1 BACKGROUND

Stress corrosion cracking (SCC) is a generic term describing the initiation and propagation of cracks that can occur in metals when subjected to stress in the presence of an enabling chemical environment. The stress can originate from an externally applied force, thermal stress, or residual stress from welding or forming.

D-2 Carbon steel is susceptible to SCC when stressed in the presence of ammonia and oxygen.

Ammonia SCC has been recognized as a problem in the agricultural, chemical, and transport industries for many years.

Studies have shown that the following factors contribute to the likelihood of SCC:

a) Material yield strength greater than 344.7 MPa;
b) Oxygen contamination;
c) Residual or applied stress; and
d) Water content less than 0.2 percent.

D-3 SCC IN AMMONIA REFRIGERATION SYSTEMS

SCC in ammonia refrigeration systems is less common, but there have been reports of SCC in vessels and piping. Vessels seem to be more susceptible to SCC because of their higher material yield strengths and residual fabrication stresses. High pressure receivers are particularly vulnerable due to their potential for higher oxygen content (non-condensibles) and lower water content but SCC has also been found in low pressure vessels and piping.

Propagation of cracks via SCC is usually a gradual process. In ammonia refrigeration applications using carbon steel materials, stress corrosion cracks typically propagate from surface or sub-surface discontinuities at the interior wall of a susceptible vessel or pipe. Sufficiently high stresses can propagate crack(s) through the material to emerge as a “pinhole leak” on the external surface. Discovery of a “pinhole leak” on a vessel is indicative of SCC and it is likely that additional cracks will be present in the same vessel. Repair of stress corrosion cracks is difficult and often not cost-effective.

D-4 RECOMMENDATIONS TO INHIBIT SCC IN AMMONIA REFRIGERATION SYSTEMS

The following recommendations are intended to minimize the likelihood of SCC for vessels constructed from carbon steel for use in ammonia refrigeration systems:

a) The presence of non-condensable gases (specifically, oxygen) increases the probability of SCC. As such, purging of air from the system during both initial start-up and during operation and maintenance is important; and

b) Post-weld heat treat (PWHT) all high temperature vessels, especially vessels such as high pressure receivers, and intermediate and low temperature water chillers, intercoolers and economizers, to relieve the residual stress of welding and forming. Where low temperature vessels are critical to the process, or may be held at temperatures above – 5°C for long periods of time, consideration should be given to PWHT.

Following exceptions may be noted:

1) Compressor oil separators; and
2) Specialized vessels, such as plate heat exchangers, containing internal components that could be damaged, for example, internal bushings, gaskets.

NOTES

1 PWHT may produce significant scale, which could cause operating problems in the system.

2 Refrigerant-grade anhydrous ammonia shall meet or exceed the requirements of as per Table 1.

ANNEX E

(*Informative*)

EMERGENCY PRESSURE CONTROL SYSTEMS EMERGENCY PRESSURE CONTROL SYSTEM DESIGN AND INSTALLATION GUIDELINES

E-1 GENERAL

E-1.1 Purpose

This technical guideline describes requirements for emergency pressure control systems (EPCS), which provide a means of internally mitigating an overpressure event in a refrigeration system that is independent of other required safety features and functions prior to operation of a pressure relief device.

E-1.2 Scope

Emergency pressure control systems used as a means to mitigate an overpressure event involving an ammonia refrigeration system should comply with this technical guideline.

E-1.3 Limitations

An EPCS does not reduce or eliminate requirements for pressure relief devices set forth in other codes and standards.

E-2 DEFINITIONS

E-2.1 Crossover Valve — It is a valve that allows interconnection of two different portions of a refrigeration system that normally operate at different pressures.

E-2.2 Emergency Pressure Control System (EPCS) — It is a system consisting of pressure sensors, independent compressor cut-off controls and automatically controlled crossover valves that will permit a high-pressure portion of a system to connect to a lower pressure portion of a system when opened.

E-2.3 Header — It is a pipe to which other pipes or tubes are connected.

E-2.4 Highside — Consists of those parts of a mechanical refrigerating system that are subjected to approximate condenser pressure.

E-2.5 Lowside — Consists of those parts of a mechanical refrigerating system that are subjected to approximate evaporator pressure.

A pressure sensor is a mechanical or electronic device that measures ammonia pressure.

E-2.6 Seep — It is a nuisance loss of refrigerant from a relief valve that can occur when the vessel pressure approaches the relief pressure setting, or a nuisance loss of refrigerant from a relief valve that can occur after the valve discharges if the valve does not fully reset.

E-2.7 Zone — It is a general term used to identify a pressure level or temperature level of a refrigeration system. A zone will be associated with a compressor or group of compressors and the associated.

E-2.8 Vessels — Serving a common pressure level. The term does not pertain to individual temperature-controlled areas or rooms served by one or more compressor.

E-3 REFERENCE STANDARDS

E-3.1 IS 3594 and Part – IV of SP 7 shall be referred.

E-4 EMERGENCY PRESSURE CONTROL SYSTEM (EPCS) RECOMMENDED.

Each zone should be provided with an EPCS. Each EPCS, other than the lowest pressure zone, should include a crossover valve to allow an abnormally high pressure to be discharged to a lower pressure zone.

E-4.1 Design and Installation Recommendations

E-4.2 Crossover Valve Connections

E-4.2.1 Crossover valves should be connected to locations that will allow pressure in each high pressure zone to discharge to a lower pressure zone. Connections between pressure zones should continue in the above-described manner until all major pressure zones in a system are connected with the EPCS, always with the intended flow traveling from a high pressure to a lower pressure.

E-4.2.2 Where multiple low-pressure zones are present, low-pressure zones with the highest pressure should be connected to the next lowest pressure zone.

E-4.2.3 Crossover valve connections should not be to pipes or tubes conveying liquid refrigerant.

E-4.2.4 High pressure crossover valve connections should come from the top of a dry suction header, compressor discharge header or other main gas header.

E-4.2.5 Low pressure crossover valve connections should discharge to the vapour space in a receiving vessel or to a common vapour header serving multiple receiving vessels.

E-4.2.6 The designer of a refrigeration system should consider the ability of the low pressure portion of the system to receive the high pressure discharge from the EPCS crossover valve. Operation of the crossover valve should not cause a release of refrigerant from pressure relief devices on the low pressure portion of the system.

E-4.2.7 Crossover valves and connecting piping and valves should have a minimum nominal size of 1 inch.

E-4.2.8 Piping and tubing associated with a crossover valve should be independent of any other connections. The connection should not be in the same pipe or tube where a pressure relief device is connected.

E-4.3 Crossover Valve Type

The crossover valve should be of a type that fully opens when activated.

E-4.4 Isolation Valves

E-4.4.1 Each crossover valve should be provided with a stop valve on either side to allow isolation of the crossover valve for maintenance.

E-4.4.2 Isolation valves should be locked in the open position during normal operations.

E-4.5 System Operation

E-4.5.1 The EPCS should be arranged for automatic operation.

E-4.5.2 Where required by the fire department, the EPCS should be provided with a remote switch for manual activation.

E-4.5.3 An EPCS should be arranged to activate at a pressure not greater than 90 percent of the pressure relief device setting.

E-4.5.4 A dedicated, independent mechanical pressure switch or a combination of a mechanical and electronic pressure-sensing device dedicated to the EPCS should be provided to activate each EPCS.

E-4.5.5 Pressure sensing equipment should continuously monitor pressure in the refrigeration system adjacent to each crossover valve.

E-4.5.6 When a pressure sensor reaches the EPCS activation pressure, all of the following should occur:

a) All compressors supplying the pressure zone that is in an over-pressure condition should be stopped by a means that is independent of all other safety controls;
b) Associated crossover valves should open; and
c) Condenser fans and pumps should be stopped if the system pressure falls below 90 psig.

E-4.5.7 A means should be provided to signal personnel responsible for refrigeration system maintenance that an EPCS has been activated.

E-4.5.8 Once an EPCS has been activated, it should remain active until manually reset.

E-4.6 Inspection and Maintenance

E-4.6.1 *General*

EPCS crossover valves and isolation valves should be inspected and tested on an annual basis to verify proper operation.

E-4.7 Written Procedures

E-4.7.1 *General*

Written procedures should be in place to describe the operation of the EPCS. Procedures should address the importance of maintaining isolation valves in the full open position unless maintenance is being performed on the crossover valve.

E-4.7.2 *Considerations for Pressure Set Points*

Seep through a relief valve is nuisance refrigerant loss due to pressure differential conditions across the valve or dirt and debris located at the seat. Seep is measured in bubbles per minute and can vary from manufacturer, design, type of seat material, pressure differential across relief, amount of dirt that is trapped after a relief discharges, and age of the relief valve. Relief valves are set with a tolerance of +/–3 percent, but when these reliefs are stored or left in operation for a long period of time, the reliefs can begin to seep at larger tolerances. In some cases, seep has occurred when pressure increases to within 10 percent of relief set pressure.

One method to prevent seep, is to maintain a pressure on the relief valve of 90 percent or less of the rated relief valve pressure setting. When pressures higher than 90 percent of rated relief valve pressure setting are anticipated, it is possible to select soft seats that are bubble tight at higher pressures. Rupture disks in combination with a relief valve will result in tighter tolerances.

The following shows examples of typical tolerances and pressures associated with relief valves and the EPCS.

Example 1:

Typical set point values and tolerances for a 21 bar (2 100 kPa gauge) system

Relief full open (+ 10 percent) 23 bar (2 300 kPa gauge)

+ 3 percent tolerance 21.63 bar (2 163 kPa gauge)

Relief valve set point 23 bar (2 300 kPa gauge)

–3 percent tolerance 23.37 bar (2 337 kPa gauge)

Potential seep point (–10 percent) 18.9 bar (1 890 kPa gauge)

EPCS set point 16.89 bar to 18.9 bar (1 689 kPa to 2 100 kPa gauge) (EPCS set point is equal or below the seep point)

Design system operating Pressure

(–25 percent) 15.75 bar (1 575 kPa gauge) (system operating pressure should be 25 percent lower than the relief valve setting when selecting relief valves)

Compressor off set point 15.75 bar (1 575 kPa gauge)

Example 2:

Typical set point values and tolerances for a 16.89 bar (1 689 kPa gauge) system

relief full open (+ 10 percent) 19.25 bar (1 925 kPa gauge)

+ 3 percent tolerance 18 bar (1 800 kPa gauge)

Relief valve set point 16.89 bar (1 689 kPa gauge)

–3 percent tolerance 16.89 bar (1 689 kPa gauge)

Potential seep point (-10 percent) 15.75 bar (1 575 kPa gauge) (EPCS set point is equal or below the seep point)

EPCS set point 14.7 bar to 15.75 bar (1 470 kPa to 1 575 kPa gauge)

Design system operating pressure (–25 percent) 14 bar (1 400 kPa gauge)

(system operating pressure should be 25 percent lower than the relief valve setting when selecting relief valves)

Compressor off set point 14 bar (1 400 kPa gauge)

ANNEX F

(*Informative*)

MACHINE ROOM SIGNS

The following example of the principal and auxiliary machinery room doors are provided for reference only (*see* Fig. 1 and 2).

F-1 KEY TO DOOR SIGNAGE

F-1.1 Refrigeration Machinery Room — Authorized Personnel Only

Color: Black text, yellow background

Location: All entrances to machinery room

F-1.2 Caution — Ammonia R-717

Color: Black text, yellow background

Location: All entrances to machinery room

F-1.3 Caution — Eye and Ear Protection must be Worn in this Area

Color: Black text, yellow background

Location: All entrances to machinery room

F-1.4 Warning — When Alarms are Activated Ammonia has been Detected

a) Leave room immediately when alarms are activated;
b) Do not enter except by emergency trained personnel only; and
c) Do not enter without personal protective equipment.

Location: All entrances to machinery room.

F-1.5 Refrigeration Machinery Shutdown, Emergency Use Only

Colour: Black text, orange background.

Location: Designated principal exterior machinery room door.

F-1.6 Refrigeration Machinery Room — Refrigeration Ventilation, Emergency Use Only

Colour: Black text, orange background

Location: Designated principal exterior machinery room door, also can be used for remote ON/OFF/AUTO ventilation switch.

F-7 AMMONIA FIRE DIAMOND

Colour: Black text, white, blue, red and yellow background

Location: All entrances to machinery room

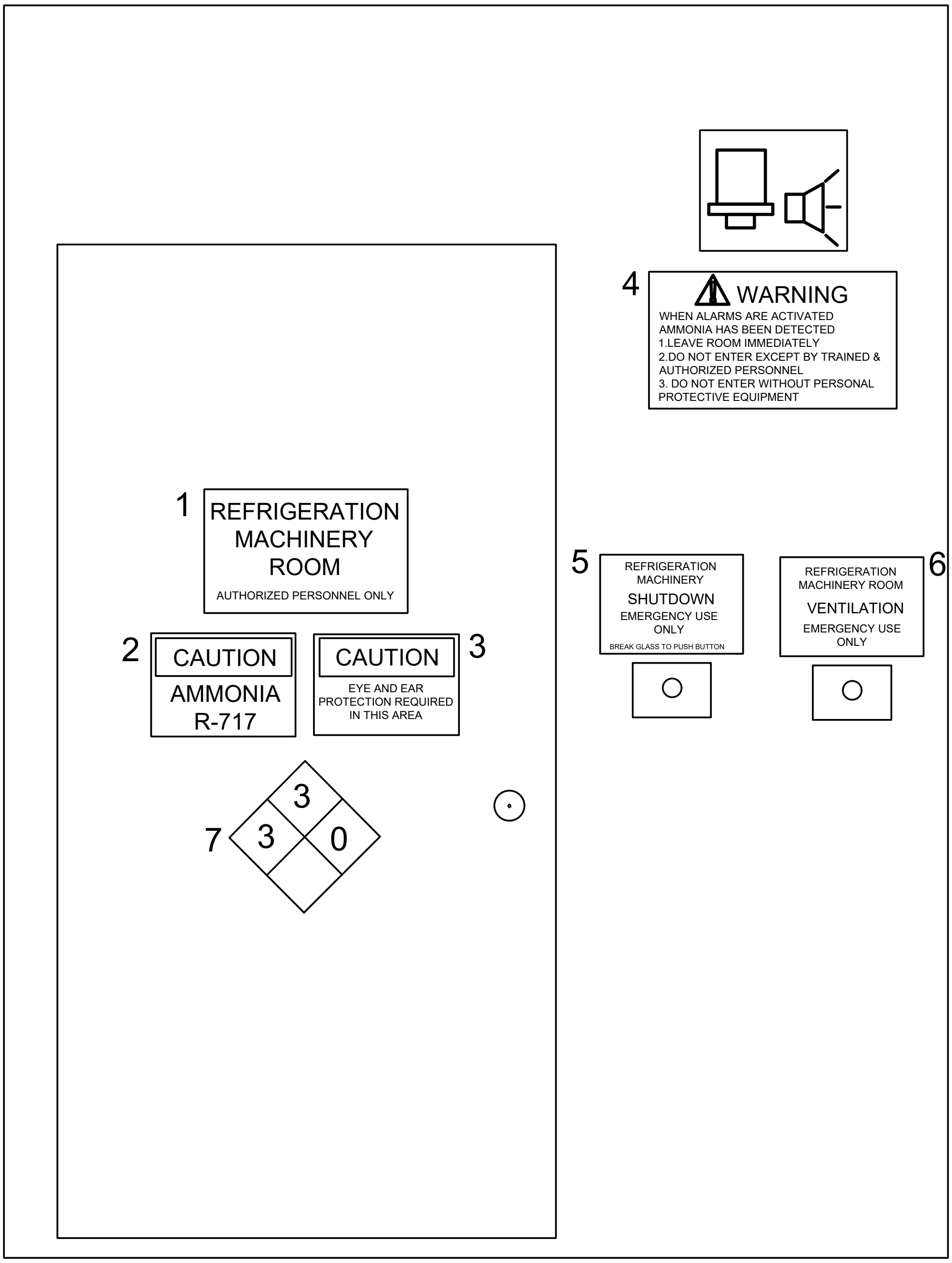


Fig. 1 Principal Machinery Room Door

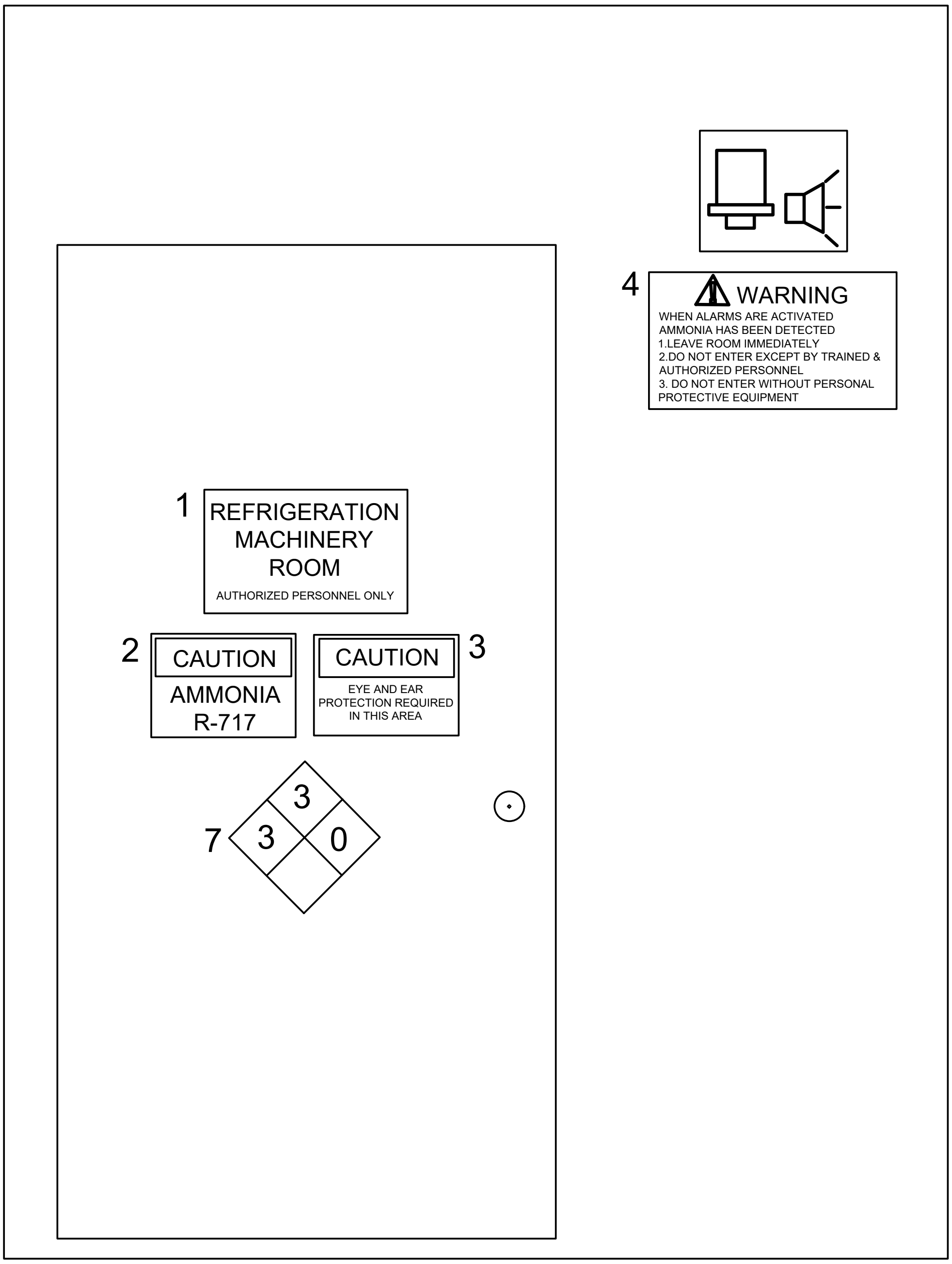


Fig. 2 Auxiliary Machinery Room Door

ANNEX G

(*Informative*)

ALTERNATIVE VENTILATION CALCULATION METHODS

G-1 GENERAL

The note to **6.14.7.1** describes alternative ventilation methods that are available for ammonia (NH_3) refrigeration systems. This Annex contains sample calculations for the design of alternative ventilation methods.

G-2 SAMPLE CALCULATION

30 air changes per hour (ACH) for emergency ventilation rate.

G-2.1 Design the ventilation system for an ammonia refrigeration skid package that contains 204.117 kg (450 lb) of anhydrous ammonia (G) and is located in a machinery room that has a volume (F) of 2 831.68 m^3 (100 000 ft^3).

1 kg = 2.21b and 1m = 3.28 ft

G-2.2 The emergency ventilation rate equation (30 ACH = 0.5 air changes/minute):

$Q = V$ 0.5 (air changes/min)

where

Q = airflow in m^3/s (ft^3/min); and

V = room volume in m^3 (ft^3).

For this example:

Q = (100 000 ft^3) 0.5 (air changes/min) = 50 000 ft^3/min

G-3 SAMPLE CALCULATIONS

Demonstrate that ammonia concentrations will never exceed 40 000 ppm [25 percent of the lower flammability limit (LFL)].

G-3.1 Demonstrate that the ammonia concentrations would never exceed 40 000 ppm if 100 lb of anhydrous ammonia (G) were released from an ammonia refrigeration skid package located in a machinery room that has a volume (V) of 2 831.68 m^3 (100 000 ft^3).

G-3.2 The following equation can be used to demonstrate that the ammonia concentrations would never exceed 40 000 ppm:

$C = G$ (vapour specific volume) • (100 percent)/V

where

C = volumetric concentration of ammonia in percent;

G = amount of ammonia released in the room in kg (lb). For the purposes of these calculations it is assumed that the entire ammonia inventory is released and vapourized inside the machinery room; and

Vapour specific volume = the vapour specific volume for anhydrous ammonia in m^3 (ft^3) = room volume, in m^3 (ft^3).

Vapour specific volumes at 1.034 bar (15 psia)

Sl No. (1)	*Temperature (°C)* (2)	*Temperature (°F)* (3)	*Specific Volume (ft^3/lb)* (4)	*Specific Volume (kg/m^3)* (5)
i)	4.44	40	20.688 0	331.389
ii)	15.55	60	21.564 1	345.422
iii)	26.66	80	22.433 8	359.342
iv)	37.77	100	23.298 5	373.206

For this example:

C = (100 lb) • (22.433 8 ft^3lb at 80 °F) • (100%)/(100 000 ft^3) = 2.24%

The LFL percent for anhydrous ammonia is typically considered to be to 16 percent (160 000 ppm). Twenty-five percent of the LFL is 4 percent (40 000 ppm). Thus, under steady- state conditions, the ammonia concentration inside the machinery room (2.24 percent) would not exceed 40 000 ppm, even if the entire ammonia charge were released and vapourized within the machinery room.

G-3.3 Even though the calculations demonstrate that under steady-state conditions the ammonia concentrations would never exceed 40 000 ppm, it is recommended that an emergency ventilation system be provided in the machinery room in this example. The emergency ventilation rate used would be at the discretion of the designers.

G-4 SAMPLE CALCULATIONS

Provide localized (spot) ventilation designed to maintain ammonia concentrations below 40 000 ppm.

G-4.1 Design a localized (spot) ventilation system for an ammonia refrigeration skid package that contains 113.4 kg (250 lb) of anhydrous ammonia (G) and is located in a machinery room which has a volume (V) of 2 831.68 m^3 (100 000 ft^3) that will maintain the ammonia concentrations below 40 000 ppm. Assume temperature to be 15.55°C (60°F).

G-4.2 The following equation can be used to calculate the ventilation rate for a localized (spot) ventilation system that will maintain the ammonia concentrations below 40 000 ppm.

Q = (403 • SG • 100% -ER-Sf)/(M^ • LFL%. B)

where

Q = airflow in m^3/s (ft^3/min);

SG = specific gravity of ammonia liquid [SG = 0.62 at 15.55°C (60°F)]; and

ER = evaporation rate of liquid in lb/min. For the purposes of these calculations, it is assumed that the entire ammonia inventory is released and vapourized inside the machinery room over a 10 min period, that is, 250 lb over a 10 min period (25 lb/min).

Convert 25 lb/min to pnt/min: 1 pint = 0.01671 ft^3

NH liquid at 15.55°C (60°F) = 38.54 lb/ft^3

ER = 25 lb/min ft^3/38.5416 pnt/0.01671 ft^3 = 38.82 pnt/min

Sf = a safety coefficient that depends on the percentage of the LFL necessary for safe conditions. Because it has been found desirable to maintain vapour concentrations of not more than 40 000 ppm, a Sf coefficient of 4 (25 percent of the LFL) will be used for these calculations.

MW = the molecular weight of ammonia liquid (MW= 17.03);

LFL = the lower flammability limit for ammonia (LFL = 16 percent); and

B = a constant that takes into account the fact that the LFL decreases at elevated temperatures. B = 1 for temperatures up to 250°F; B = 0.70 for temperatures above 250°F, though it is unlikely that temperatures above 250°F would ever be applicable for an ammonia refrigeration system.

For this example

B = 1

Q = [(403) • (0.62 at 60°F) • (100%) • (38.82 pints/min) • (4)]/[(17.03) • (16%) • (1)]

= 14 238.9 ft^3 min

G-4.3 Industrial Ventilation

G-4.3.1 Locate the exhaust openings near the sources of contamination, if possible, to obtain the benefit of “spot ventilation.”

G-4.3.2 Locate the air supply and exhaust outlets such that the air passes through the zone of contamination. The operator should remain between the air supply and the sources of the contaminant.

G-4.3.3 Replace the exhausted air by use of a replacement air system.

G-4.3.4 Avoid re-entry of the exhausted air by discharging the exhaust high above the roof line and by ensuring that no window, outdoor air intakes, or other such openings are located near the exhaust discharge.

ANNEX H

(*Informative*)

PIPE FITTINGS, FLANGES AND BOLTING

The following criteria for materials have historically been commonly used in the ammonia refrigeration industry for ammonia pipe, fittings, flanges and bolting.

H-1 PIPE

Seamless carbon steel pipes for weld connection should be as per Table 3.

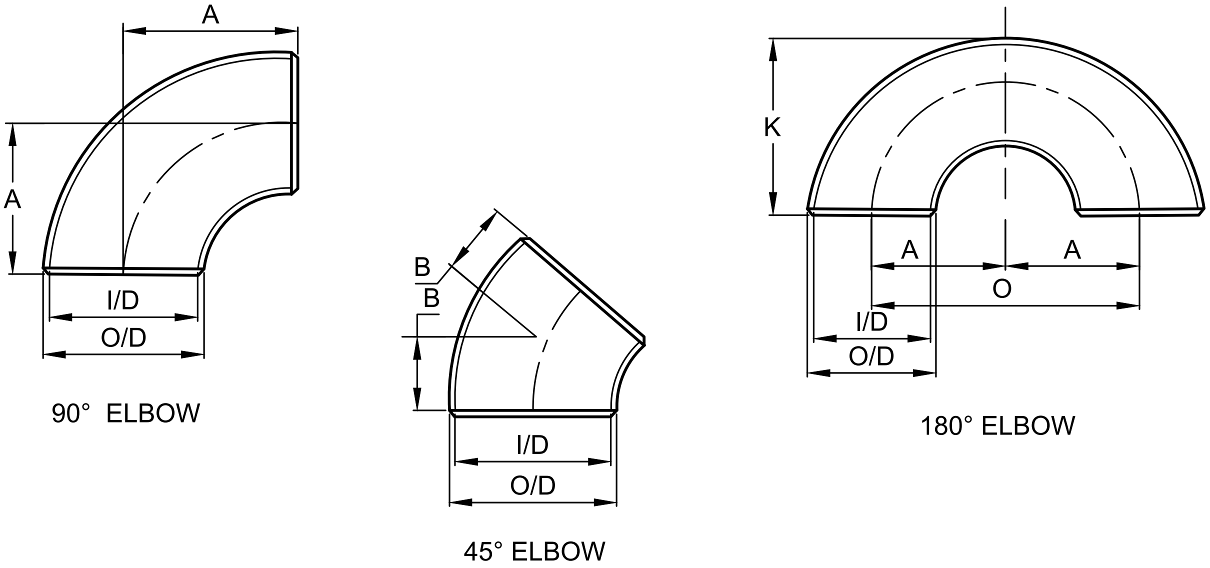
Seamless carbon steel pipes for threaded connection should be as per Table 4.

Stainless steel pipes for weld connection should be Table 5.

Stainless steel pipes for threaded connection should be Table 6.

H-2 ELBOW

(*See* Fig. 3).



90° ELBOW

45° ELBOW

180° ELBOW

FIG. 3 ELBOW DRAWING

Sl No.	*Nominal Pipe Size (NPS)*	*Outside Diameter at Bevel (O/D) in degree*	*Dimension A in degree*	*Dimension B in degree*	*Center to Center O in degree*	*Back to Face K in degree*
(1)	(2)	(2)	(3)	(4)	(5)	(6)
i)	1/2”	21.3	38	16	76	48
ii)	3/4”	26.7	38	19	76	51
iii)	1”	33.4	38	22	76	56
iv)	1.1/4”	42.2	48	25	95	70
v)	1.1/2”	48.3	57	29	114	83
vi)	2”	60.3	76	35	152	106
vii)	2.1/2”	73	95	44	190	132
viii)	3”	88.9	114	51	229	159
ix)	3.1/2”	101.6	133	57	267	184
x)	4”	114.3	152	64	305	210
xi)	5”	141.3	190	79	381	262
xii)	6”	168.3	229	95	457	313

Sl No. (1)	*Nominal Pipe Size (NPS)* (2)	*Outside Diameter at Bevel (O/D) in degree* (2)	*Dimension A in degree* (3)	*Dimension B in degree* (4)	*Center to Center O in degree* (5)	*Back to Face K in degree* (6)
xiii)	8”	219.1	305	127	610	414
xiv)	10”	273	381	159	762	518
xv)	12”	323.8	457	190	914	619
xvi)	14”	355.6	533	222	1 067	711
xvii)	16”	406.4	610	254	1 219	813
xviii)	18”	457	686	286	1 372	914
xix)	20”	508	762	318	1 524	1 016
xx)	22”	559	838	343	1 676	1 118
xxi)	24”	610	914	381	1 829	1 219
xxii)	26”	660	991	406	—	—
xxiii)	28”	711	1 067	438	—	—
xxiv)	30”	762	1 143	470	—	—
xxv)	32”	813	1 219	502	—	—
xxvi)	34”	864	1 295	533	—	—
xxvii)	1/2”	21.3	—	—	—	—
xxviii)	3/4”	26.7	—	—	—	—
xxix)	1”	33.4	25	—	51	41
xxx)	1.1/4”	42.2	32	—	64	52
xxxi)	1.1/2”	48.3	38	—	76	62
xxxii)	2”	60.3	51	—	102	81
xxxiii)	2.1/2”	73	64	—	127	100
xxxiv)	3”	88.9	76	31.6	152	121
xxxv)	3.1/2”	101.6	89	36.8	178	140
xxxvi)	4”	114.3	102	42.1	203	159
xxxvii)	5”	141.3	127	52.6	254	197
xxxviii)	6”	168.3	152	63.4	305	237
xxxix)	8”	219.1	203	84.2	406	313
xl)	10”	273	254	105.2	508	391
xli)	12”	323.8	305	126.3	610	467
xlii)	14”	355.6	356	147.3	711	533
xliii)	16”	406.4	406	168.3	813	610
xliv)	18”	457	457	189.4	914	686
xlv)	20”	508	508	210.4	1 016	762
xlvi)	22”	559	559	231.5	1 118	838
xlvii)	24”	610	610	252.5	1 219	914

NOTE — 1 inch = 2.54 cm

H-3 FLANGES

Technical Specifications Flanges 1 034 kPa Pressure Rating

Sl No.					*Length Through Hub ‘Y’*				*Bore ‘B’*				
	Nominal Pipe Size (NPS)	*Outside Diameter of Flange ‘O’*	*Thickness of Flange ‘C’*	*Diameter of Hub ‘X’*	*Threaded Slip on Socket Welding*	*Lapped*	*Weld Neck ‘L21’*	*Thread length ‘T’*	*Slip on socket Welding*	*Lapped ‘B3’*	*Weld Neck Socket Welding*	*Counter bore Threaded Flange ‘C1’*	*Depth of Socket ‘D’*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
i)	1/2”	88.9	11.2	30.226	15.748	15.748	47.752	15.748	22.352	22.86	15.748	9.652	—
ii)	3/4”	98.6	12.7	38.1	15.748	15.748	52.324	15.748	27.686	28.194	20.828	11.176	—
iii)	1”	108	14.2	49.276	17.526	17.526	55.626	17.526	34.544	35.052	26.67	12.7	—
iv)	1 ¼”	117.3	15.7	58.674	20.574	20.574	57.15	20.574	43.18	43.688	35.052	14.224	—
v)	1 ½”	127	17.5	65.024	22.352	22.352	61.976	22.352	49.53	50.038	40.894	15.748	—
vi)	2”	152.4	19.1	77.724	25.4	25.4	63.5	25.4	61.976	62.484	52.578	17.526	—
vii)	2 ½”	177.8	22.4	90.424	28.448	28.448	69.85	28.448	74.676	75.438	62.738	19.05	—
viii)	3”	190.5	23.9	107.95	30.226	30.226	69.85	30.226	90.678	91.44	77.978	20.574	—
ix)	3 ½”	215.9	23.9	122.174	31.75	31.75	71.374	31.75	103.378	104.14	90.17	—	—
x)	4”	228.6	23.9	134.874	33.274	33.274	76.2	33.724	116.84	116.84	102.362	—	—
xi)	5”	254	23.9	163.576	36.576	36.576	88.9	36.576	143.764	144.526	128.27	—	—
xii)	6”	279.4	25.4	192.24	39.624	39.624	88.9	39.624	170.688	171.45	154.178	—	—
xiii)	8”	342.9	28.4	246.126	44.45	44.45	101.6	44.45	221.488	222.25	202.692	—	—
xiv)	10”	406.4	30.2	304.8	49.276	49.276	101.6	49.276	276.352	277.368	254.508	—	—
xv)	12”	482.6	31.8	365.252	55.626	55.626	114.3	55.626	327.152	328.168	304.8	—	—
xvi)	14”	533.4	35.1	400.05	57.15	79.248	127	57.15	359.156	360.172		—	—
xvii)	16”	596.9	36.6	457.2	63.5	87.376	127	63.5	410.464	411.226	To be specified by purchaser	—	—
xviii)	18”	635	40.1	504.952	68.326	96.774	139.7	68.326	461.772	462.28	—	—	—
xix)	20”	698.5	42.9	558.8	73.152	103.124	144.526	73.152	513.08	514.35	—	—	—
xx)	24”	812.8	47.8	663.448	82.55	111.252	152.4	82.55	615.95	615.95	—	—	—

NOTE — All dimensions in mm except NPS

Technical Specifications Flanges 2 068 kPa Pressure Rating

Sl No.					*Length Through Hub ‘Y’*				*Bore ‘B’*				
	Nominal Pipe Size (NPS)	*Outside Dia of Flange ‘O’*	*Thickness of Flange ‘C’*	*Dia of Hub ‘X’*	*Threaded Slip on Socket Welding*	*Lapped*	*Weld Neck ‘L21’*	*Thread length ‘T’*	*Slip on socket Welding*	*Lapped ‘B3’*	*Weld Neck Socket Welding*	*Counter bore Threaded Flange ‘C1’*	*Depth of Socket ‘D’*
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)	(13)	(14)
i)	1/2”	95.3	14.2	38.1	22.352	22.352	52.324	15.748	22.352	22.86	15.748	23.622	9.652
ii)	3/4”	117.3	15.7	47.752	25.4	25.4	57.15	15.748	27.686	28.194	20.828	28.956	11.176
iii)	1”	124	17.5	53.848	26.924	26.924	61.976	17.526	34.544	35.052	26.67	35.814	12.7
iv)	1 ¼”	133.4	19.1	63.5	26.924	26.924	65.024	20.574	43.18	43.688	35.052	44.45	14.224
v)	1 ½”	155.4	20.6	69.85	30.226	30.226	68.326	22.352	49.53	50.038	40.894	50.292	15.748
vi)	2”	165.1	22.4	84.074	33.274	33.274	69.85	28.448	61.976	62.484	52.578	63.5	17.526
vii)	2 ½”	190.5	25.4	100.076	38.1	38.1	76.2	31.75	74.676	75.438	62.738	76.2	19.05
viii)	3”	209.6	28.4	117.348	42.926	42.926	79.248	31.75	90.678	91.44	77.978	92.202	20.574
ix)	3 ½”	228.6	30.2	133.35	44.45	44.45	81.026	36.576	103.378	104.14	90.17	104.902	—
x)	4”	254	31.8	146.05	47.752	47.752	85.852	36.576	116.078	116.84	102.362	117.602	—
xi)	5”	279.4	35.1	177.8	50.8	50.8	98.552	42.926	143.764	144.526	128.27	144.526	—
xii)	6”	317.5	36.6	206.248	52.324	52.324	98.552	45.974	170.688	171.45	154.178	171.45	—
xiii)	8”	381	41.1	260.35	61.976	61.976	111.252	50.8	221.488	222.25	202.692	222.25	—
xiv)	10”	444.5	47.8	320.548	66.548	95.25	117.348	55.626	276.352	277.368	254.508	276.352	—
xv)	12”	520.7	50.8	374.65	73.152	101.6	130.048	60.452	327.152	328.168	304.8	328.676	—
xvi)	14”	584.2	53.8	425.45	76.2	111.252	142.748	63.5	359.156	360.172	—	360.426	—
xvii)	16”	647.7	57.2	482.6	82.55	120.65	146.05	68.326	410.464	411.226	—	411.226	—
xviii)	18”	711.2	60.5	533.4	88.9	130.048	158.75	69.85	461.772	462.28	—	462.026	—
xix)	20”	774.7	63.5	587.248	95.25	139.7	162.052	73.152	513.08	514.35	—	512.826	—
xx)	24”	914.4	69.9	701.548	106.426	152.4	168.148	82.55	615.95	615.95	—	—	—

NOTE — All dimensions in mm except NPS

H-4 BOLTING

Properties for bolt are as follows:

Tensile strength of 60 to 100 ksi

Chemical Composition

C: 0.295

Mn: 1.2 percent,

P: 0.04 percent,

S: 0.05 percent ,

Elongation percent: *Min* -18

Properties for nuts are as follows:

Chemical composition

C: 0.4 percent,

Mn: 1 percent,

Si: 0.40 percent,

P: 0.04 percent,

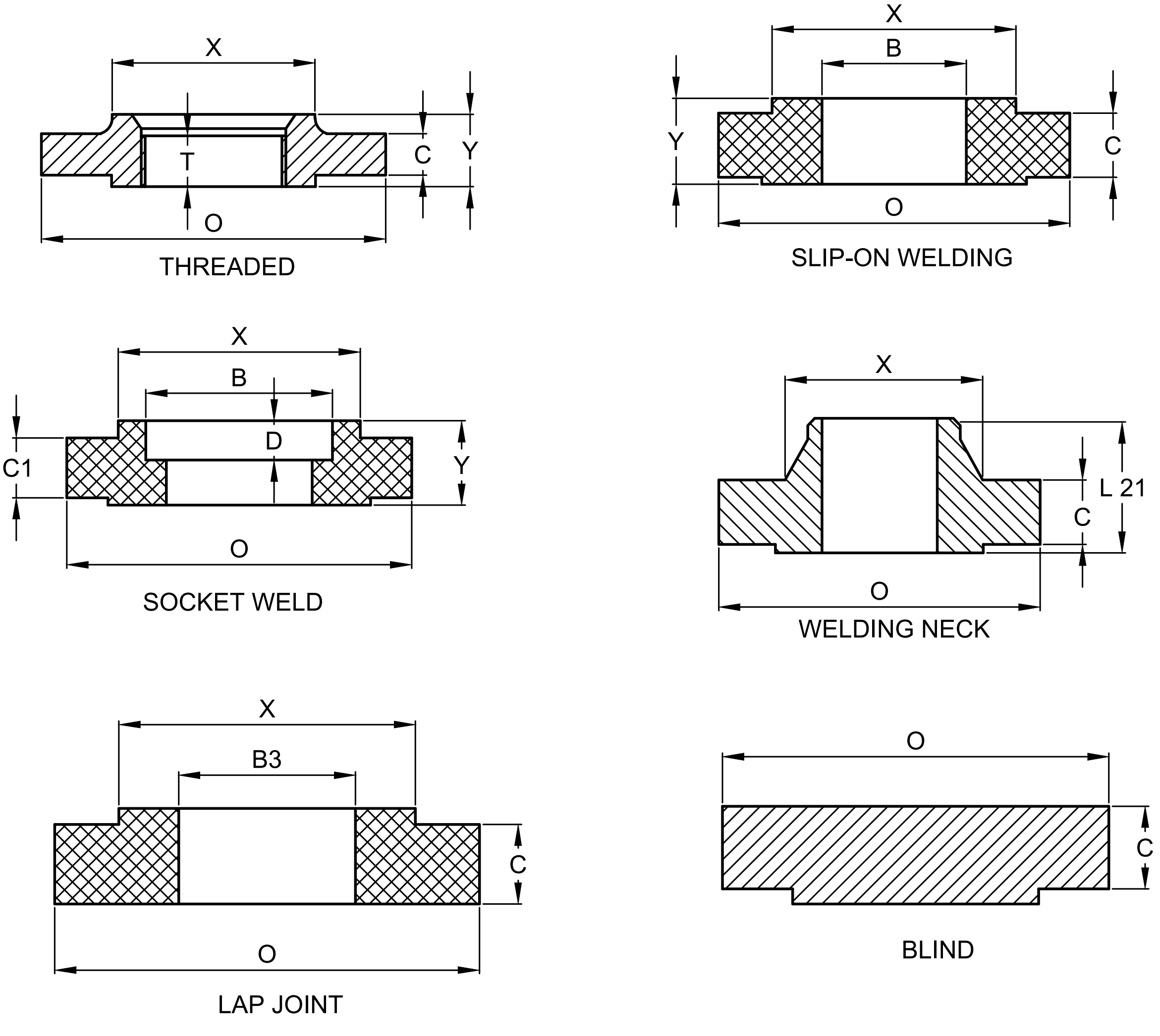
S: 0.05 percent,

Proof load stress 175 ksi *Min*,

Hardness Rockwell: *Min* C-24, *Max* C-38.

NOTE — The above materials refer to those common materials in joining piping flanges only. These materials or other commonly used qualifying materials selected for a safe design are permitted for bolts and studs for equipment closures, valve bonnet-body connection, etc.

Flange drawing for H3 is shown in Fig. 4



THREADED

SLIP-ON WELDING

SOCKET WELD

WELDING NECK

LAP JOINT

BLIND

FIG. 4 H3 FLANGE DRAWING

ANNEX J

(*Informative*)

SAFE PRACTICE IN CASE OF LEAK AFFECTING OCCUPANTS

J-1 THE BRIEF PROCEDURE IN CASE OF LEAKS AFFECTING PEOPLE

Liquid ammonia spill is more dangerous than gas leakage and when in contact with skin can cause third degree burns and may lead to blindness.

J-1.2 Steps to be taken in Case Ammonia Leaks

Do not spray water on ammonia liquid leak, wipe it with cloth as ammonia having large latent heat property can cause cloud formation if water is spread on it.

Shower a person with ammonia injuries for 5 to 15 min with water.

At this time the person should wear mask to ensure that ammonia vapours are not inhaled.

J-1.3 During Showering Cautiously Remove the Clothes

Decontaminate the victim as quickly as possible. Start with the eyes. The whole body, or exposed area, must be flushed with generous amounts of water; this includes the hair, ears, under the chin, and armpits. Water sources such as showers, hoses, eye wash stations, or stock tanks are acceptable.

J-1.4 Eyes

Ensure trained personnel and adequate first aid supplies are readily available.

J-1.4.1 *Contact with the Eyes*

Even if only a small amount of ammonia enters the eyes, irrigate the eyes with an abundance of water for a minimum of 15 min. Continually and thoroughly flush the entire eye surface and the inner lining of the eyelids. Eyes affected by ammonia close involuntarily, so the eyelids must be held open so that water can flush the entire eye surface, as well as the inner lining of the eyelid.

If there is no physician available, continue irrigation for an additional 15 min.

Do not wear contact lenses when handling anhydrous ammonia. If ammonia gets in the eyes, the ammonia will get trapped under the lenses causing even more damage. They may also prevent immediate flushing of the eye surface.

Serious eye injury should be treated by an ophthalmologist, but in an emergency, wash with large quantities of water for 15 min or more as quickly as possible. In fact, the only real hope for preventing permanent eye injury lies in quick and generous washing.

One suggestion for those likely to be exposed is to carry a small, eight-ounce squeezable squirt bottle filled with water, which can be used to get excess ammonia out of the eyes until a larger water supply can be reached. This small amount of water is not sufficient to remove all the ammonia. It is essential that the eyes be irrigated for a minimum of 15 min as soon as possible.

Another emergency method is to duck the head in water and rapidly blink and move or rotate the eyes.

J-1.5 Contact with the Skin

It is essential that any ammonia spilled on the worker be removed immediately and that the worker be moved to an uncontaminated area quickly.

Clothes that have been saturated by liquid ammonia may freeze to the skin. In any case, the victim, still clothed, should get immediately under a shower, if available, or jump into a stock tank, pond, or into any other source of water. Time is important. Remove clothes only after they are thawed and they can be freely removed from frozen areas. If the clothing is removed incorrectly, whole sections of skin can be torn off.

No salves, creams, ointments, or jellies should be applied to the skin during a 24 h period following the injury since this will prevent natural elimination of the ammonia from the skin. After the 24 h period, the medical treatment is the same for thermal burns. A physician should view any second or third-degree freeze burns of the skin.

J-1.6 Taken Internally

The following should be done if ammonia is ingested:

a) Call a physician;
b) If conscious, have the victim drink large amounts of water;
c) Do not induce vomiting if the victim is in shock, in extreme pain, or is unconscious; and
d) If vomiting begins, place the victims face down with head lower than hips. This prevents vomit from entering the lungs and prevents severe injury.

J-1.7 Inhalation

In all inhalation exposures, severe or minimal following should be done:

a) Take the exposed workers at once to a clean, uncontaminated area;
b) Watch workers exposed to low concentrations for a short period of time. They will usually require no treatment and can be released;

c) For severe exposure to higher concentrations: Call a physician;

d) Administer oxygen by an individual who is trained and authorized to do so by a physician. This will help relieve pain and symptoms of lack of oxygen;

e) Begin artificial respiration immediately if the patient is not breathing; and

f) Keep victim warm (but not hot) and rested until transported to the hospital.

J-1.8 Summary

In any accident involving contact with ammonia with the eyes or skin following should be done:

a) Immediately flush the affected area with large quantities of clean water;

b) Place the injured person into a container of clean water or under an emergency shower; and

c) Provide the injured worker with first aid treatment and call a physician at once in the case of extreme exposure. Give the physician a complete account of the incident.

Seconds count, therefore the ammonia should be washed away with water immediately.

ANNEX K

(*Informative*)

PHYSICAL PROPERTIES OF AMMONIA

K-1 AMMONIA CHARACTERISTICS

The term ammonia, as used in this standard, refers to the compound formed by combination of nitrogen and hydrogen, having the chemical formula NH_3. It is not to be confused with aqua ammonia, which is a solution of ammonia gas in water. Whenever the term ammonia appears in this standard, it means refrigerant-grade anhydrous ammonia.

Experience has shown that ammonia is difficult to ignite and under normal conditions is a very stable compound. It requires temperatures of 450-500°C [723.2-773.2 K] to cause it to dissociate slightly at atmospheric pressure. The flammable limits at atmospheric pressure are 15.5 percent to 27 percent by volume of ammonia in air. An ammonia-air mixture in an iron flask does not ignite below 651.1°C [925.3 K].

Since ammonia is self-alarming, it serves as its own warning agent so that a person is not likely to voluntarily remain in concentrations which are hazardous.

Sl No. (1)	*Characteristics* (2)	*Metric* (3)	*SI* (4)
i)	Molecular symbol	NH_3	NH_3
ii)	Chemical name(inorganic compound)	717	717
iii)	Safety group classification	B2L	B2L
iv)	Molecular weight	17.031 g/mol	17.031 g/mol
v)	Boiling point at one atmosphere	–33.33°C	239.82 K
vi)	Freezing point at one atmosphere	–77.66°C	195.5 K
vii)	Critical temperature	132.22°C	405.37 K
viii)	Critical pressure MPa (gauge)	115.6 kg/cm^2 (gauge)	11.34 kPa
ix)	Latent Heat at –28°F (–33°C) (240.15 K) and one atmosphere	327.1 cal/g	1.369 MJ/kg
x)	Relative density of vapour compared to dry air at 32°F (0°C) (273.15 K) and one atmosphere	0.596 7	0.596 7
xi)	Vapour density at at –28°F (–33°C) (240.15 K) and one atmosphere	0.889 6 kg/m^3	0.889 6 kg/m^3

Sl No. (1)	*Characteristics* (2)	*Metric* (3)	*SI* (4)
xii)	Specific gravity of liquid at −28°F (−33°C) (240.15K) compared to water at 39.40 F (4.0 °C) (277.1K)	0.681 6	0.681 6
xiii)	Liquid density at −28°F (−33°C) (240.15K) and one atmosphere	681.6 kg/m^3	681.6 kg/m^3
xiv)	Specific volume of vapour at 32°F (0°C)(273.15K)	1.299 m^3/kg	1.299 m^3/kg
xv)	Flammable limits by volume in air at atmospheric pressure	15.5 to 27 percent	15.5 to 27 percent
xvi)	Ignition temperature	651.1°C	924.13 K
xvii)	Specific heat, gas at 15°C (288.15 K) and at one atmosphere		
xviii)	At constant pressure (C_p)	0.518 4 cal/g°C	2.170 6 kJ/kgK
xix)	At constant volume (C_v)	0.392 8 cal/g°C	1.644 4 kJ/kgK
xx)	Ratio of specific heats k (C_p/C_v) also γ at 15°C (288.15 K)	1.320	1.320

NOTES

1 One standard atmosphere = 14.696 psia (1.033 3kg/cm^2 absolute) (101.33 kPa absolute).

2 Flammability - Although ammonia is combustible it burns to form water and nitrogen. It has a relatively high lower flammable limit (LFL) (16 percent v/v), relatively low heat of combustion (19 MJ/ mol) and relatively low burning velocity (7.7 cm/s). It is not possible to ignite ammonia from a mechanical spark, and it is not possible to sustain combustion in the open air. It is necessary to ensure that there are no naked flames or other sources of ignition, and no combustion equipment, such as gas boilers or heaters in the refrigeration machinery room. For these reasons it is not necessary to design ammonia machinery rooms as if for flammable atmospheres; there are no naked flames in the room and that the electrical supply to all equipment in the room is isolated in the event of a high ammonia concentration in the atmosphere. Equipment which must remain live in the event of an ammonia alarm, such as ventilation fans and emergency lighting should be certified for use in flammable atmospheres.

3 Toxicity-The toxicity of ammonia does not require substantial special measures to be taken in the design of the machinery room. The self-alarming smell of ammonia ensures that there is no risk of a dangerous concentration arising in an occupied space without being noticed. Ammonia smell is detectable 5ppm onwards. The smell of ammonia is noticeable at about by almost all people at 25 ppm and is overpoweringly unpleasant at 500 ppm, but is not likely to cause any injury at these levels.

Sl No. (1)	*Gas concentration (PPM)* (2)	*Effect on unprotected Human Being* (3)	*Time* (4)
i)	25	Detected by most	No health hazard exposure for long duration-Unlimited time
ii)	50	Smell is very distinct. The experienced person wants to get away from the area	8 hours per day and week is permitted in most countries
iii)	100	No dangerous effects on healthy persons, minor irritation, anxiety	Do not stay longer than necessary
iv)	400-700	Immediate irritation in eyes, nose and respiratory organs. Persons used to ammonia also cannot stay	Under normal circumstances no serious injuries during 1 hour
v)	1 700	Cough, cramp and serious irritation in nose, eyes, respiratory organs	Hour exposure can lead to serious injuries
vi)	2 000-5 000	Cough, cramp and serious irritation in nose, eyes, respiratory organs	Hour exposure can lead to death
vii)	7 000	Paralyzed, suffocation	Lethal within few minutes

4 Refrigeration classification as per IS 16656/ISO 817.

Sl No. (1)	*Flammability* (2)	*Lower Toxicity* (3)	*Higher Toxicity* (4)
i)	Higher Flammability	A3	B3
ii)	Lower Flammability	A2	B2
iii)	Lower Flammabilty Burning velocity of less than 10 cm/s	A2L	B2L
iv)	No Flame Propogation	A1	B1

ANNEX L

(*Foreword*)

COMMITTEE COMPOSITION

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This Indian Standard has been developed from Doc No.: MED 03 (14430).

Amendments Issued Since Publication

Amend No.	Date of Issue	Text Affected

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Published by BIS, New Delhi